TM 11-5821-212-35

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

FIELD AND DEPOT MAINTENANCE MANUAL

RADIO TRANSMITTING SET AN/FRT-51

HEADOUARTERS, DEPARTMENT OF THE ARMY

21 OCTOBER 1960

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the 5,000-volt dc high-voltage circuits, or on the 220-volt ac line connections.

DON'T TAKE CHANCES!

DANGEROUS RF VOLTAGES ARE EXPOSED AT THE RF OUTPUT METERS AND AT THE TRANSMISSION LINE ANTENNA COUPLER TERMINALS.

5,000 VOLTS DC EXIST IN THE FOLLOWNG UNITS OF THIS EQUIPMENT:

Radio Frequency Amplifier AM–1154A/G
Power Supply PP–1234/G

TECHNICAL MANUAL
No. 11-5821-212-35

HEADQUARTERS,
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WASHINGTON 25, D. C., *21 October 1960*

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CHAPTER 1

THEORY

Section I. INTRODUCTION

1. Scope

a. This manual covers field and depot maintenance of Radio Transmitting Set AN/FRT–51. It includes instructions appropriate to third, fourth, and fifth echelons for troubleshooting and testing the control circuits that interconnect the major components of this set. Instructions for aligning, repairing the equipment, replacing maintenance parts, and repairing specific maintenance parts are covered in separate technical manuals (*b* below). Detailed functions of the control circuits between the major components are covered in the individual technical manuals.

b. The complete set of technical manuals for this equipment includes: TM 11–5821–212–10, TM 11–5821–212–20, TM 11–5820–215–35, and TM 11–5820–350–35.

c. Forward comments concerning this manual to the Commanding Officer, U. S. Army Signal Materiel Support Agency, ATTN: SIGMS–PA2d, Fort Monmouth, N. J.

Note. For applicable forms and records, see paragraph 2, TM 11–5821–212–10.

2. Application

Radio Transmitting Set AN/FRT–51 is referred to throughout this manual as the transmitting set. The transmitting set accepts two separate audio input channels (100 cycles per second (cps) to 6 kilocycles (kcs)) to produce twin- or single-sideband (ssb) transmission for long-distance point-to-point communications. When used as part of a communications system that contains multiplexing equipment the transmitting set provides communication facilities for multi-channel transmission of speech and teleprinter signals.

Section II. BLOCK DIAGRAM

3. General

The transmitting set consists of the five major components shown in figure 1. The detailed circuit analysis of Modulator-Oscillator Group OA–2180/FRT–51 is covered in TM 11–5820–215–35. The detailed circuit analysis of Radio Frequency Amplifier AM–1154A/G, Power Supply PP–1234/G, and Control Amplifier C–1637A/GR is covered in TM 11–5820–350–35. The circuit details of Electrical Dummy Load DA–212/FRT–51 are provided in this manual (para 20 and 21).

4. Modulator Oscillator Group OA–2180/FRT–51

(fig. 1)

a. Audio frequency signals are applied to the twin-sideband (tsb) modulator compartment of the modulator-oscillator. These signals are combined with a signal from the frequency standard compartment to produce a 300-kc tsb signal that is applied to the exciter-monitor. Automatic load compensation (alc) voltage from the power amplifier (pa) stage in Radio Frequency Amplifier AM–1154A/G controls the amplitude

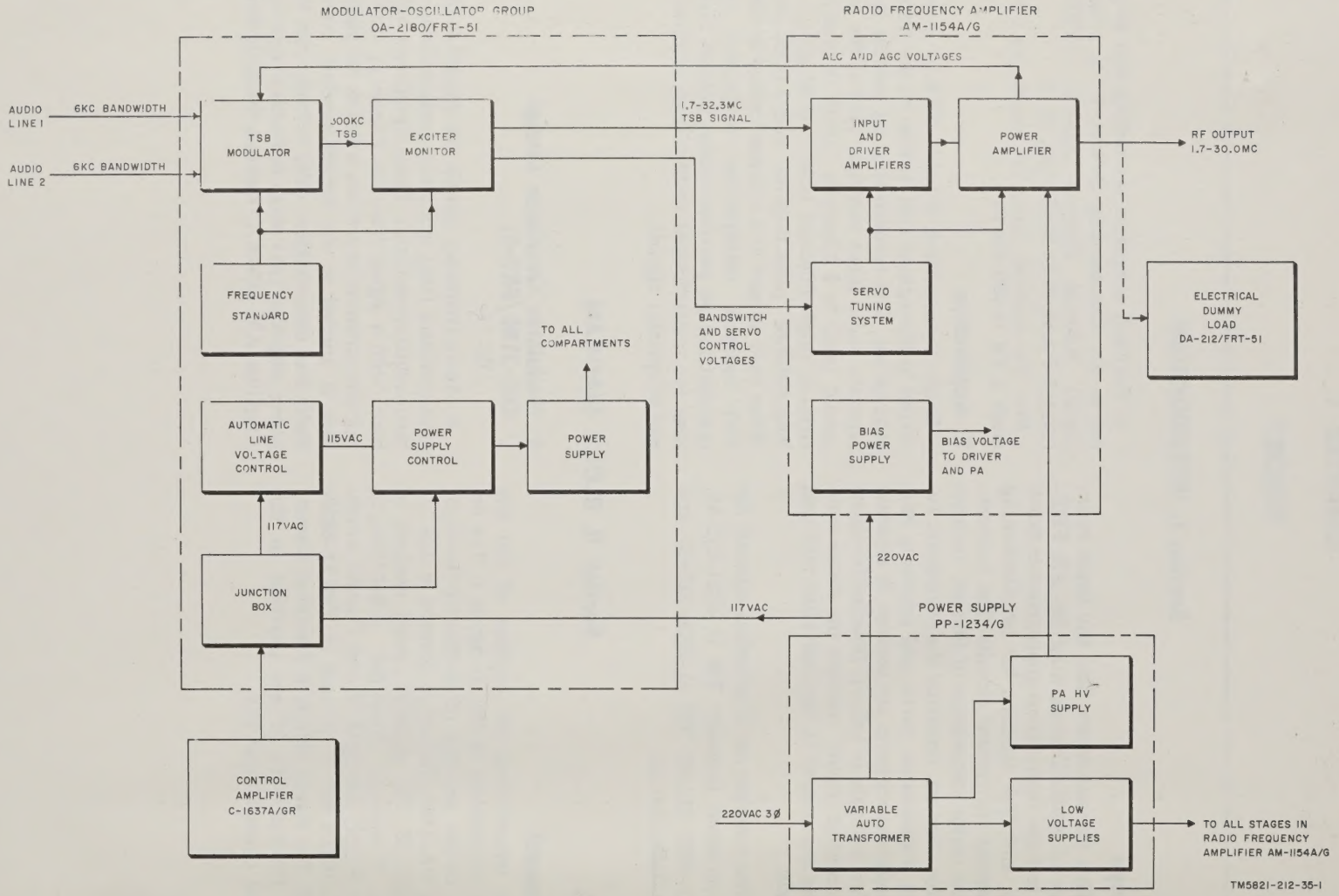

Figure 1. Radio Transmitting Set AN/FFRT 51, simplified block diagram.

of the signal applied to the exciter-monitor. This makes possible the use of full power output capabilities of the power amplifier stage when only one sideband is being used without danger of overloading when the other sideband circuit is put into use. An automatic gain control (agc) voltage, also fed back from the pa stage, is combined with an alc-controlled direct-current (dc) voltage that biases the exciter-monitor output stages and thus controls the amplitude of the excitation signal applied to Radio Frequency Amplifier AM–1154A/G.

b. The frequency standard compartment develops a number of highly accurate frequencies. One of these frequencies is applied to the tsb modulator (*a* above). The remaining frequencies are applied to frequency-correction networks within the exciter-monitor.

c. The exciter-monitor accepts the 300-kc tsb signal from the tsb modulator and mixes this signal with the output of an internal oscillator to produce the 1.7–32.3 megacycle (mc) twin- or single-sideband excitation signal that is applied to the AM–1154A/G.

d. Line voltage for the OA–2180/FRT–51 is obtained from Power Supply PP–1234/G and is routed through the AM–1154A/G cabinet and junction box to the automatic line voltage control panel. The output of this panel is a closely regulated 115 volts alternating current (ac) that is applied to the power supply chassis of the modulator-oscillator. The power supply control panel controls the application of filament and plate power. The power supply chassis provides the correct operating potentials to all the compartments in the modulator-oscillator.

5. Control Amplifier C–1637A/GR
(fig. 1)

Control Amplifier C–637A/GR is a remote control unit that enables an operator to place the transmitting set on the air and select the type of operation and power from a remote position. The remote control unit contains controls that duplicate the function of similar controls on the rf amplifier and modulator-oscillator. Indicator lights on the remote control unit reveal operating conditions in the transmitting set.

6. Radio Frequency Amplifier AM–1154A/G

Radio Frequency Amplifier AM–1154A/G, referred to throughout this manual as the rf amplifier, contains units as illustrated in figure 1. The input signal from the modulator-oscillator controls rf amplifier band switching and provides an actuating voltage to the servotuning system. The input and driver amplifiers excite the pa stage to develop the required rf output power at 1.7–30.0 mc that is coupled to an antenna system or, during test procedures, to a dummy antenna. The servotuning system automatically tunes the input and driver amplifier stages and tunes and loads the pa stage. Operating potentials are obtained from Power Supply PP–1234/G which furnishes alternating current and direct current. A voltage-regulated bias power supply supplies negative bias potentials to the driver and pa stage. Alc and agc voltages are developed in the pa stage and are fed back to the tsb modulator (para 4*a*).

7. Electrical Dummy Load DA–212/FRT–51
(fig. 1)

Electrical Dummy Load DA–212/FRT–51, referred to throughout this manual as the dummy antenna, provides a load impedance for the transmitting set during operational tests and adjustments. Interlocking circuits between the pa stage and the blower in the dummy antenna turns off the transmitting set whenever the blower stops.

8. Power Supply PP–1234/G

Power Supply PP–1234/G, referred to throughout this manual as the hv power supply, provides the necessary ac and dc supplies required for operation of the rf amplifier. The power input to the hv power supply is 220 volts, 60 cps, three phase. Taps on the variable autotransformer provide ac to the power supplies within the modulator-oscillator and the bias power supply in the rf amplifier.

Section III. SIGNAL PATH

9. Tsb Modulator
(fig. 2)

The signal path from the input to the tsb modulator to the output from the power amplifier is illustrated in figure 2. All stages that do not affect the signal directly have been omitted. For detailed circuit analysis of the various stages discussed in this section, refer to the individual technical manuals (para 1) covering this equipment.

a. The tsb modulator contains modulator and frequency converter circuits for producing a 300-kc twin-sideband. One (if single-sideband is desired) or two audio frequency inputs may be applied to the input of the tsb modulator. Sideband selector switches select the sideband that the vf input will occupy (upper or lower). The sideband interchange relays insure that, despite the number of mixing processes through which the input signal passes, the vf input will automatically occupy the desired sideband. (The exact number of mixing processes is determined by the frequency of transmission selected.)

b. The two vf inputs are applied to separate balanced modulators where each input is heterodyned with a 100-kc signal (from the frequency standard compartment) to form upper and lower sidebands of 100 kc. The undesired sideband from each balanced modulator is removed by filters and the remaining sideband signals are combined to form a twin-sideband signal with an upper sideband that has information from one vf input and a lower sideband that has information from the other vf input. The 100-kc signal is attenuated at this point. The exact amount of the carrier attenuation is determined by the receiving system to be used with this transmitting set.

c. The 100-kc twin-sideband output of the balanced modulator is applied to a frequency converter stage. This stage mixes the 100-kc twin-sideband input signal with a 400-kc signal to produce a 300-kc twin-sideband signal that is applied to the mixer-amplifier stages within the exciter-monitor.

10. Exciter-Monitor
(fig. 2)

The 300-kc twin-sideband signal from the tsb modulator is applied to the mixer-amplifier section of the exciter-monitor. The mixer-amplifiers heterodyne the 300-kc twin-sideband signal with conversion signals from the stabilized master oscillator (smo). The conversion signals are stabilized by frequency-correction circuits that compare the smo-generated signals with the frequencies generated by the frequency standard compartment. The 1.7–32.3–mc twin-sideband output of the mixer-amplifiers is applied to the input amplifier of the rf amplifier. (Although the mixer-amplifiers are capable of producing frequencies up to 32.3 mc, the highest frequency attainable with this equipment is 30.0 mc because the rf amplifier will not tune above this frequency.)

11. Rf Amplifier Stages in AM–1154A/G
(fig. 2)

The rf amplifier provides linear amplification to the twin-sideband input signal and amplifies the 0.1-watt input power to 4 kilowatts of peak envelope power at any frequency within the tuning range. The input amplifier serves as an impedance-matching device between the 50-ohm coaxial input cable and the rf stages. The signal is amplified and applied to the buffer stage. The buffer isolates the loading effects of the driver from the input stage. The output of the buffer is applied to the driver stage. The driver provides driving signals for the power amplifier stage. The power amplifier amplifies the rf signal from the driver to the required output level.

Section IV. INTERUNIT CONTROL FUNCTIONS

Note. The major components of the transmitting set are interconnected by control circuits. Application of plate power to the major components may be controlled from the front panel controls on the rf amplifier and modulator-oscillator or from a remote control unit. The modulator-oscillator group controls the band switching function and tuning of the rf amplifier. The rf amplifier controls the carrier reinsertion function during the tuneup cycle and provides agc and alc levels to the modulator-oscillator. These control functions are covered in this section.

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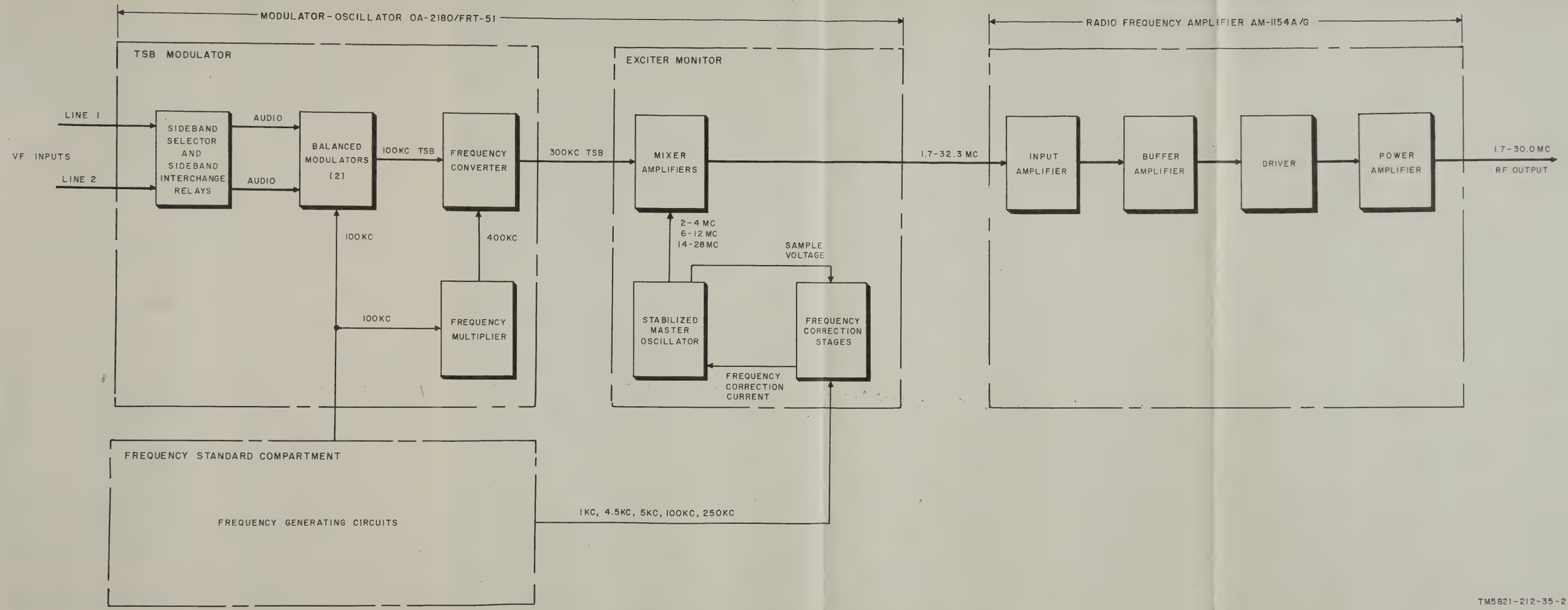


Figure 2. Signal path of transmitting set, simplified block diagram.

12. Primary Power Interconnection
(fig. 3)

The modulator-oscillator group receives primary power (117 volts ac) from transformer T7404 located in the rf amplifier cabinet. The input voltage is applied through circuit breaker LINE SWITCH S3801 (fig. 7, TM 11–5821–212–10), which is located on the front panel of the modulator-oscillator junction box, and applied to the automatic line voltage control panel.

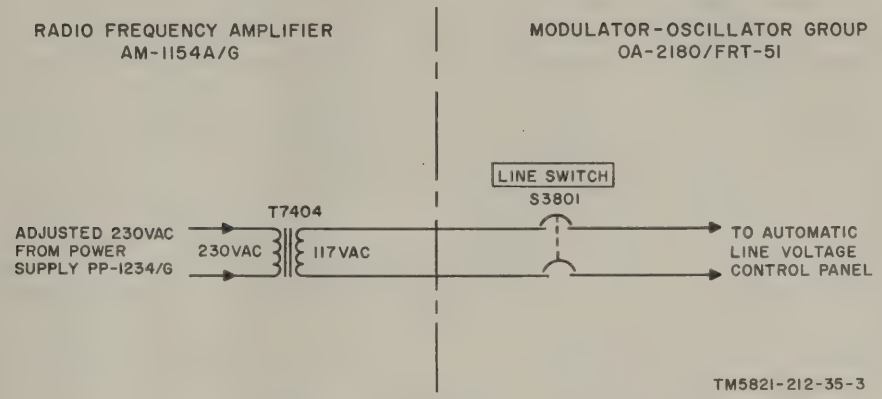


Figure 3. Primary power interconnection, schematic diagram.

13. Plate Control Circuits
(fig. 4)

a. General. Plate power for the rf amplifier can be controlled from the remote control unit when CONTROL switch S7406 is placed in the REMOTE position. When S7406 is in the LOCAL position, the rf amplifier can only be turned on by the front panel controls on the rf amplifier. The plate power for the modulator-oscillator can be controlled from the remote control unit or the front panel of the modulator-oscillator regardless of the position of the control switch. All the ON switches in this equipment are the momentary-contact type and the OFF switches are the momentary open-circuit type. There are no remoting facilities for controlling the filament and bias circuits of the major components of the transmitting set.

b. Remote Operation.

(1) When CONTROL switch S7406 is placed in the REMOTE position, operation of ON switch S9701 applies 117 volts ac to latch relay K7401. The circuit path is through the coil of latch relay K7401, contacts 5–12 of K7404, contacts 7–13 of K7409, contacts 12–4 of K7402, REMOTE contacts of S7406, momentarily closed contacts of S9701, normally closed contacts of S9702 and to the 117-volt ac source through the REMOTE contacts of S7402, and OFF-STANDBY switch S7406, the normally closed contacts S7405.

(2) When latch relay K7401 is energized, contacts 7–13 close and power is applied to plate relay K6002, which, in turn, energizes the plate circuits of the rf amplifier. Holding contacts 5–12 of K7401 also close when this relay is energized. When ON switch S9701 releases to break the ac circuit, the circuit path for latch relay K7401 remains completed through its holding contacts (5–12), bypassing the open ON switch. When OFF/RESET switch S9702 is pressed, the circuit is momentarily opened, latch relay K7401 is deenergized, and holding contacts 5–12 are released. The circuit can only be turned on by pressing the ON switch again because when OFF/RESET switch S9702 returns to its normally closed position, the holding

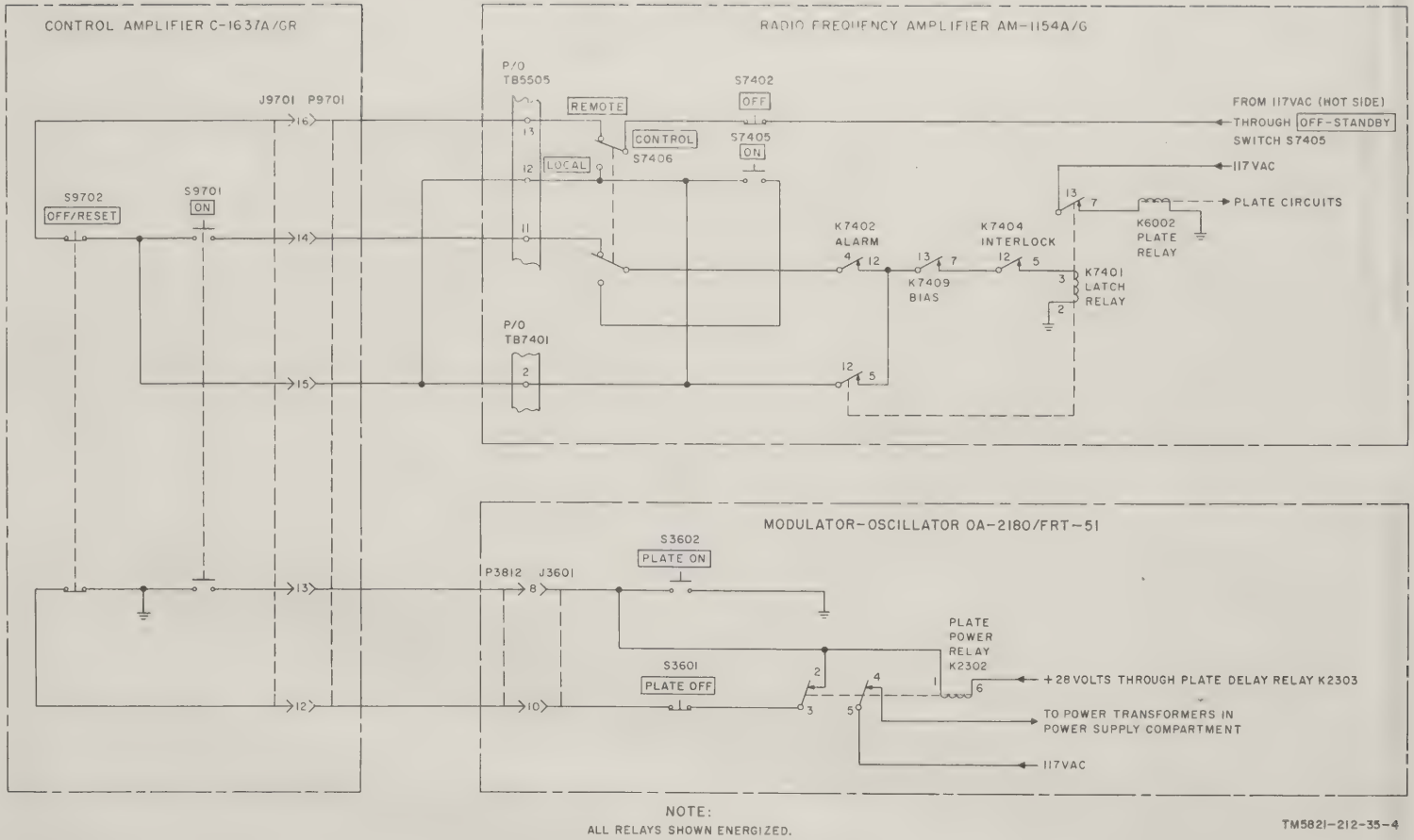


Figure 4. Plate control circuits, partial schematic diagram.

contacts of relay K7401 will remain open.

(3) When ON switch S9701 is pressed, it also completes the circuit to the modulator-oscillator plate power relay K2302. Relay current (+28-volt dc) is routed through S9701, terminal 13 of J9701 and P9701, terminal 8 of P3812 and J3601, the coil of K2302, and through plate delay relay K2303 to +28 volts. When plate power relay K2302 is energized, holding contacts 2–3 and contacts 4–5 close completing the ac path for the plate power transformers in the power supply compartment of the modulator-oscillator. When ON switch S9701 releases, dc current for K2302 is routed through the two series-connected off switches (S9702 and S3601) and holding contacts 2–3 of K2302. Pressing either of the series-connected off switches, S9702 or S3601, will open the circuit path through the holding contacts, deenergizing relay K2302, and remove the line voltage from the power transformers.

c. Local Operation.

(1) When CONTROL switch S7406 is placed in the LOCAL position, the remote control unit is switched out of the rf amplifier control circuit. Pressing ON switch S7405 energizes latch relay K7401 and power is applied to plate relay K6002. The circuit path for the latch relay is similar to that described for remote operation (*b* above), except that the circuit is completed through the LOCAL contacts of S7406, the momentarily closed contacts of S7405, the normally closed contacts of S7402, and switch S7405. When the ON switch contacts are released, the relay coil of K7401 is kept energized through holding contacts 5–12 which bypass the open contacts of S7405. Pressing OFF switch S7402 breaks the circuit path for the holding contacts that deenergize latch relay K7401.

(2) The modulator-oscillator front panel PLATE ON and PLATE OFF switches are similar in operation to the ON and OFF/RESET switches on the remote control unit. These switches control the application of dc voltage to K2302 in the same manner as that described in *b*(3) above.

14. Tuneup and Carrier Reinsert Control Circuits

(fig. 5)

a. General. The rf amplifier and modulator-oscillator are interconnected by control circuits that automatically place the transmitting set into a tune cycle (at reduced power) whenever the automatic tuning system in the rf amplifier detects a frequency change or a tuning error in the rf stages, or when the relay control discriminator V4801 in the modulator-oscillator detects a frequency or phase error within the frequency-generating stages of the exciter-monitor section. When the error is corrected or the frequency change cycle is completed, relays automatically function to return the transmitting set to normal power. Thus, the tuning function can be initiated by either the rf amplifier or the modulator-oscillator. These functions are described in *b* and *c* below.

b. Tuning Function Initiated by Rf Amplifier. The rf amplifier may be placed in the tune cycle by manually placing POWER selector switch S7407 in the TUNE position. This action energizes tune relay K7413. The rf amplifier is automatically placed in the tune cycle whenever the rf amplifier servosystem detects a frequency change. When this occurs, contacts 713 of automatic tuning relay K7416, and contacts 2–8 of automatic tuning sequence controller K7302 close. This action completes the ac circuit for tune relay K7413, and the following sequence occurs:

(1) Contacts 3–7 of K7413 close and energize carrier reinsert relay K7301 through the door and blower interlock relays.

(2) Contacts 1–11 of K7301 open and extinguish the AUTO-TUNED light I7407. (This indicates that the transmitting set is going through a tuning cycle.)

(3) Contacts 8–14 of K7301 close, and energize servopower and automatic tuning relays.

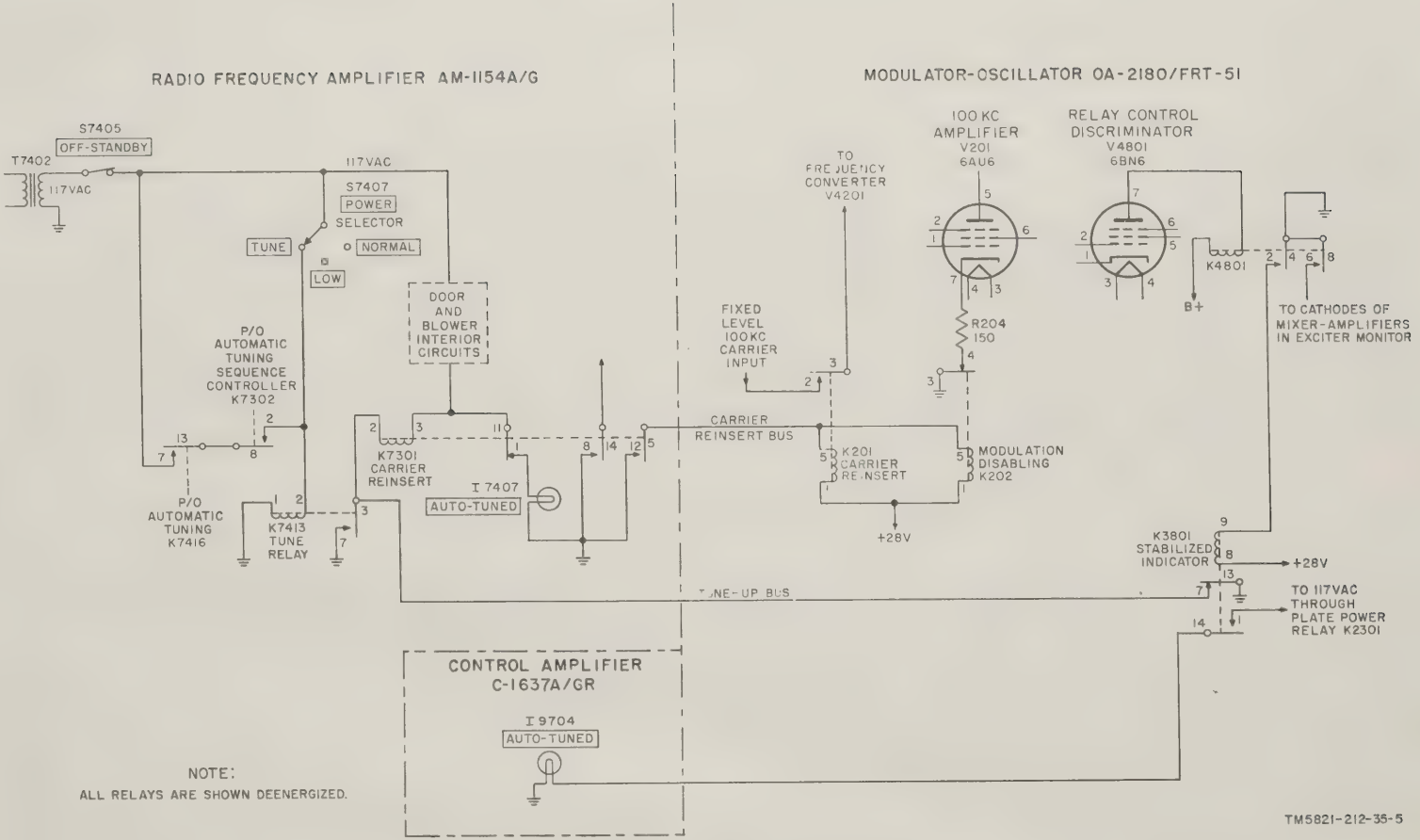


Figure 5. Carrier reinsert and tuneup control circuits.

(4) Contacts 5–12 of K7301 close. This action energizes carrier reinsert relay K201 and modulation disabling relay K202 in the tsb modulator compartment of the modulator-oscillator.

(5) When carrier reinsert relay K201 energizes, contacts 2–3 close and a fixed-level 100-kc carrier signal is applied to V4201. This signal is subsequently mixed with other frequencies to provide a carrier signal for tuning purposes.

(6) When relay K202 energizes, contacts 3–4 open; this removes the cathode ground return from V201, and prevents any modulating voltages from appearing in the output of the modulator-oscillator until the transmitting set is correctly tuned.

c. Tuning Function Initiated by Modulator-Oscillator. Relay control discriminator V4801 monitors the frequency and phase of the signal developed by the frequency-generating stages of the exciter-monitor compartment within the modulator-oscillator. When a channel selection is made or when an error is detected, the plate current through V4801 drops sharply and relay K4801 is deenergized. This action initiates the following sequence:

(1) Contacts 6–8 of K4801 open, and disable the mixer-amplifier stages of the exciter-monitor section of the modulator-oscillator; this prevents any output from the modulator-oscillator until the frequency or phase error is corrected.

(2) Contacts 2–4 of K4801 open, and deenergize relay K3801.

(3) Contacts 1–14 of K3801 open, and extinguish autotuned light I9704 in the remote control unit.

(4) Contacts 7–13 of K3801 close, and energize carrier reinsert relay K7301 in the rf amplifier cabinet. From this point, the action is identical with that described in *b*(3) through (6) above.

Note. Once K7301 is energized, it remains energized through self-holding contacts until the rf amplifier is tuned. The tuneup bus remains grounded within the rf amplifier after K3801 has been energized. This action provides time for the rf amplifier to tune up after the modulator-oscillator is tuned.

15. Automatic Tuning System Control Circuits
(fig. 6)

a. General. The tuning function of the transmitting set is controlled by the automatic tuning system (para 91 through 94, TM 11–5820–215–35) contained within the modulator-oscillator group. The selection of a channel energizes the automatic tuning system, which, in addition to positioning the tuning elements within the exciter-monitor section of the modulator-oscillator, energizes circuits within the rf amplifier that set the tunable elements to the desired band switch setting; and also supplies a carrier signal that is used by the rf amplifier servosystem to position tunable elements within the selected band to the desired operating frequency. The rf amplifier servosystem is covered in paragraphs 15 through 27 of TM 11–5820–350–35.

b. Band Switching Function. Assume that a channel selection has been made and that the selected channel frequency is within the band 2 (2.3–4.3 mc) range. A channel selection will initiate the following sequence:

(1) The automatic tuning mechanism operates a limit switch that completes the ground return for motor run relay K802.

(2) Contacts 2–3 of K802 close. This action provides a ground return for K803 and K804 (part of the automatic tuning system within the modulator-oscillator).

(3) The automatic tuning system operates to set S4405 and S4403A to position 2. Upon completion of the tuning cycle at the modulator-oscillator, the shutoff limit switch, controlled by motor B801, releases to open the ground return for K802.

(4) Contacts 2–3 break and contacts 1–2 close.

(5) When contacts 1–2 of K802 close, the following dc path for K3101 (in the rf amplifier) is completed:

(*a*) Wiper and contact 2 of S4403A.

(*b*) Contact 2 and the wiper of band-seeking switch S3102.

(*c*) Coil of band switch motor relay K3101. Through the closed set of

contacts to +28 volts, thereby energizing K3101.

(6) When relay K3101 is energized, the following sequence occurs:

(*a*) Both sets of contacts (1–2 and 3–4) controlled by K3101 open.

(*b*) When contacts 3–4 open, B+ is removed from the input amplifier plate and screen circuits, buffer screen, and alc rectifier cathode. (These circuits, in turn, control the removal of other supply voltages in the rf amplifier.)

(*c*) When contacts 1–2 open, the short circuit across band switch motor B3103 is removed.

(*d*) Band switch motor B3103 turns to position S2901, S2902, S2903, S2904, S3101, the band switch dial, and band-seeking switch S3102.

(*e*) Band-seeking switch S3102 continues to rotate until the open slot in the switch lines up with the selected contact (in this example, contact 2).

(*f*) When the slot on S3102 lines up with 2, the dc path for K3101 is interrupted. Both sets of contacts of K3101 close. One set of contacts restores B+ to the amplifier stages within the rf amplifier and the other set shorts motor B3102.

(7) The band switch mechanism remains in this condition until another channel selection is made.

c. Tuning Function. When a channel selec-

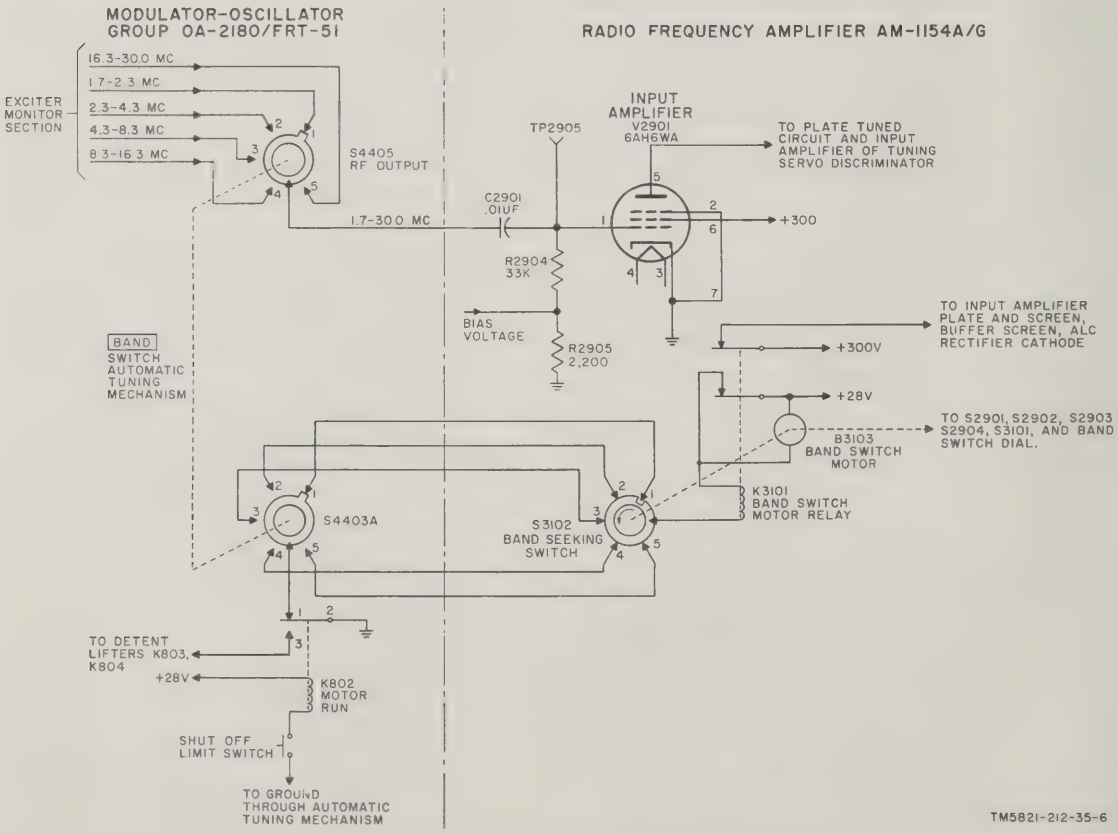


Figure 6. Band switch and tuning control interconnections.

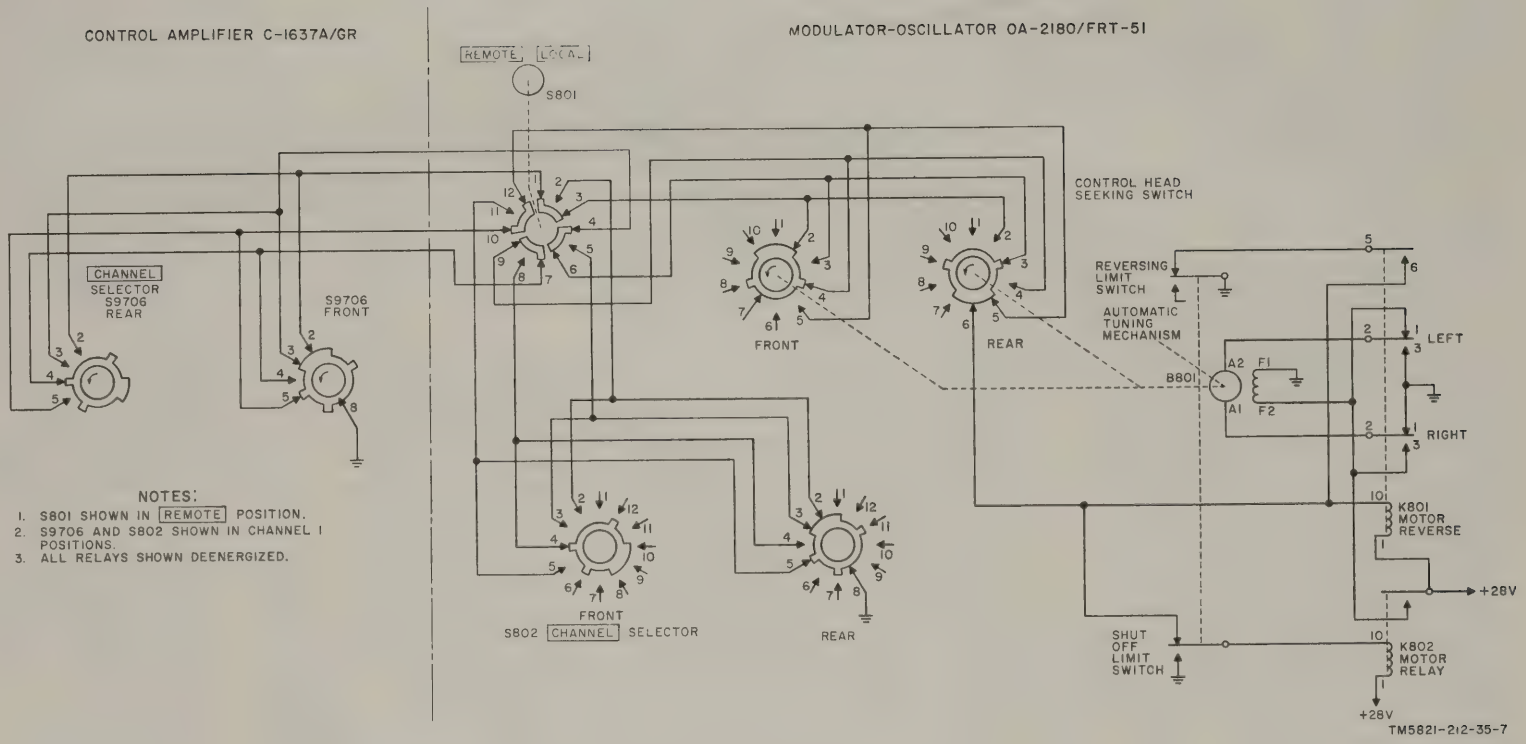


Figure 7. Remote control channel selection, interconnections.

tion is made, the automatic tuning system of the modulator-oscillator automatically positions S4405 to the band setting that is within the range of the selected channel frequency. In this example, assume that 4.2-mc was the selected frequency. The exciter-monitor section of the modulator-oscillator supplies the 4.2-mc signal through contact 2 and wiper of S4405 through C2901 to the grid of input amplifier V2901. Tube V2901 amplifies this signal and applies it to a tuning servodiscriminator network that uses this frequency to tune the variable elements within the selected band (*b* above) to the exact frequency of operation.

16. Channel Selection
(fig. 7)

a. Channel selection may be made by setting the CHANNEL selector switch, on the front panel of the exciter-monitor compartment, to the desired channel. Control Amplifier C–1637A/GR provides facilities for remote channel selection. When REMOTE LOCAL switch S801, also on the front panel of the exciter-monitor, is placed in REMOTE, exciter-monitor CHANNEL selector switch S802 is switched out of the circuit, and channel selection can only be made by CHANNEL select switch S9706 at the remote control unit. Except for switch contact numbers, switch S9706 is identical with S802.

b. The four-segment REMOTE LOCAL switch S801 permits channel selection from either the remote control unit or the modulator-oscillator by completing the circuit to the desired selector switch (S802 or S9706). Figure 7 shows switch S9706 just after a channel 1 selection was made, but before the various relays have had time to energize. When channel 1 is selected, a ground return path for motor run relay K802 and motor reverse relay K801 in the exciter-monitor compartment of the modulator-oscillator is completed through the following switch contacts:

(1) Contacts 8 (wiper) and 5 on the front of S9706.
(2) Contacts 10 and 12 (wiper) of S801.
(3) Contacts 5 and 6 of the rear section of the control-head seeking switch. (This action energizes both relays K801 and K802.)

c. When motor run relay K802 is energized, contacts 2–3 of K802 close and field winding F1-F2 of motor B801 is energized. The armature (A1-A2) is returned through the reversing contacts of K801 and through contacts 2–3 of K802 to +28 volts. Motor B801 turns to advance the control-head seeking switch until a position is reached that opens the ground return path through the control-head seeking switch. Although this action completes the channel selection function, exact positioning of the various tuning elements within the exciter-monitor compartment continues, because terminal 10 of K802 is automatically returned to ground through a shutoff limit switch that keeps K802 energized until the tuning cycle is completed. A slip-clutch arrangement on motor B801 prevents further rotation of the control-head seeking switch. The reversing limit switch, controlled by B801, completes the ground return path for motor reverse relay K801 (through holding contacts 5–6) until the tuning cycle is completed. The entire tuning sequence of the modulator-oscillator is covered in paragraph 92, TM 11–5820–215–35.

Section V. AGC AND ALC INTERCONNECTIONS

17. Block Diagram of Alc and Agc Systems
(fig. 8)

a. The agc and alc functions of the transmitting set are interrelated. The agc system prevents changes in the amplitude of the driving signal supplied to the power amplifier of Radio Frequency Amplifier AM–1154A/G that may occur because of a change in the signal level or a change in tube or component characteristic. The alc system makes possible the use of full power-output capabilities of the power amplifier when only one sideband is being used without danger of distortion because of overloading when the other sideband is put into use. All of the individual stages are covered in detail in the separate technical manuals (para 1) covering this equipment. The block diagram in figure 8 illustrates only those stages that contribute to the agc or alc functions that pertain to the operation of the complete transmitting set. Agc networks that are confined to

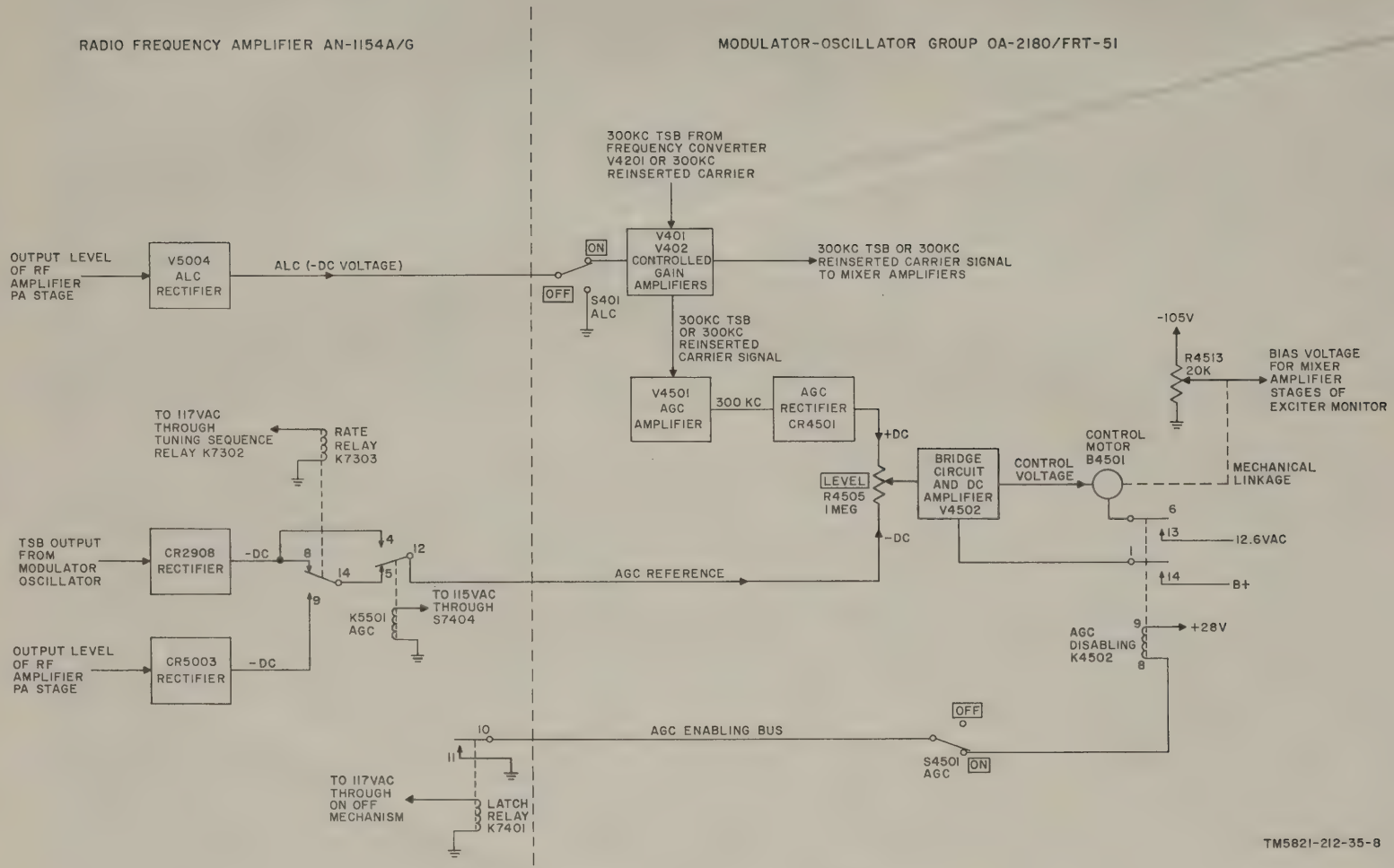


Figure 8. Alc and agc functions, block diagram.

only one of the major components are not covered in this manual.

b. The source of the agc reference voltage and the agc level depend upon the actual operating conditions of the transmitting set. The level (or absence) of the alc voltage also depends on operating conditions. When the transmitting set is turned on, power is applied to latch relay K7401. This action closes contacts 10–11 of K7401, and completes the +28-volt circuit for agc disabling relay K4502. When relay K4502 is energized, B+ is applied to the bridge and to dc amplifier circuit V4502, and 12.6 volts ac is applied to the agc control motor B4501.

c. During the rf amplifier tuneup cycle, rate relay K7303 is energized and contacts 8–14 close. A negative dc voltage (derived by rectifying a sampling of the modulator-oscillator output) is used as the agc reference voltage and is applied to one end of LEVEL control R4505 through contacts 5–12 of K5501. There is no output from alc rectifier V5004 during the tuneup cycle, and the signal applied to the controlled-gain amplifiers (V401 and V402), is a controlled-level 300-kc reinserted carrier signal. The controlled-gain amplifiers feed this 300-kc signal to agc amplifier V4501. This signal is rectified by CR4501 and applied to the other end of LEVEL control R4505. The voltage at the arm of R1505 is sensed by the bridge circuit. If the voltage is of such amplitude as to unbalance the bridge, a control voltage is applied to motor B4501 which mechanically moves the arm of R4513 to change the bias applied to the mixer-amplifiers, which, in turn, determines the amplitude of the driving signal applied to the rf amplifier. During the rf amplifier tuneup cycle, the modulator-oscillator is not governed by any amplitude level variations in the rf amplifier.

d. When the rf amplifier has completed its tuning cycle, rate relay K7303 is deenergized and contacts 9 and 14 close. An agc reference voltage (derived by rectifying a portion of the power amplifier output voltage) is applied to LEVEL control R4505 through contacts 5–12 of K5501. This agc reference voltage will sense any gain variations that may occur either in the modulator-oscillator or the rf amplifier, and control motor B4501 is signaled to adjust the bias on the mixer-amplifier stages.

e. Alc rectifier V5004 has no output voltage unless the power amplifier output level increases beyond a predetermined level. (This happens, for example, when the input to the rf amplifier is changed from single-sideband to twin-sideband.) When V5004 conducts, a negative voltage is applied to controlled-gain amplifiers V401 and V402 which will reduce the gain of these stages. A portion of the 300-kc twin-sideband output of the controlled-gain stages is applied to agc amplifier V4501, which is rectified by CR4501 and applied as a positive voltage to LEVEL control R4505. The bridge circuit senses this change and motor B4501 turns to adjust the arm of R4513, thereby changing the gain of the mixer-amplifier stages in the exciter-monitor compartment, and the amplitude of the signal delivered to the rf amplifier.

18. Agc Interconnections

(fig. 9)

a. The portion of the agc network of the rf amplifier that affects the modulator-oscillator is illustrated in figure 9. During the tuneup cycle, both relays K7303 and K5501 are energized. (When Radio Frequency Amplifier AM–1154A/G is used as part of Radio Transmitting Set AN/FRT–51, the SERVICE switch is always set to SSB and K5501 remains energized.) The tuneup carrier signal from the exciter-monitor compartment within the modulator-oscillator is rectified by CR2908; filtered by C2983, C2995, and L2916; developed across R2971; and coupled through contacts 8–14 of K7303 and contacts 5–12 of K5501 to LEVEL control R4505. This signal is the agc reference that controls the output amplitude of the modulator-oscillator during the tuneup cycle.

b. When the tuning cycle is completed, relay K7303 is deenergized and the agc reference voltage is developed across R7312. A portion of the power amplier output is applied across L5020; rectified by CR5003; filtered by C5022, C7304, and R7311; and developed across agc load resistor R7312. The agc voltage across R7312 is coupled through contacts 9–14 of K7303, contacts 5–12 of K5501, and applied to LEVEL control R4505. The agc reference applied to the modulator-oscillator under these conditions is a function of the rf amplifier power amplifier stage output amplitude.

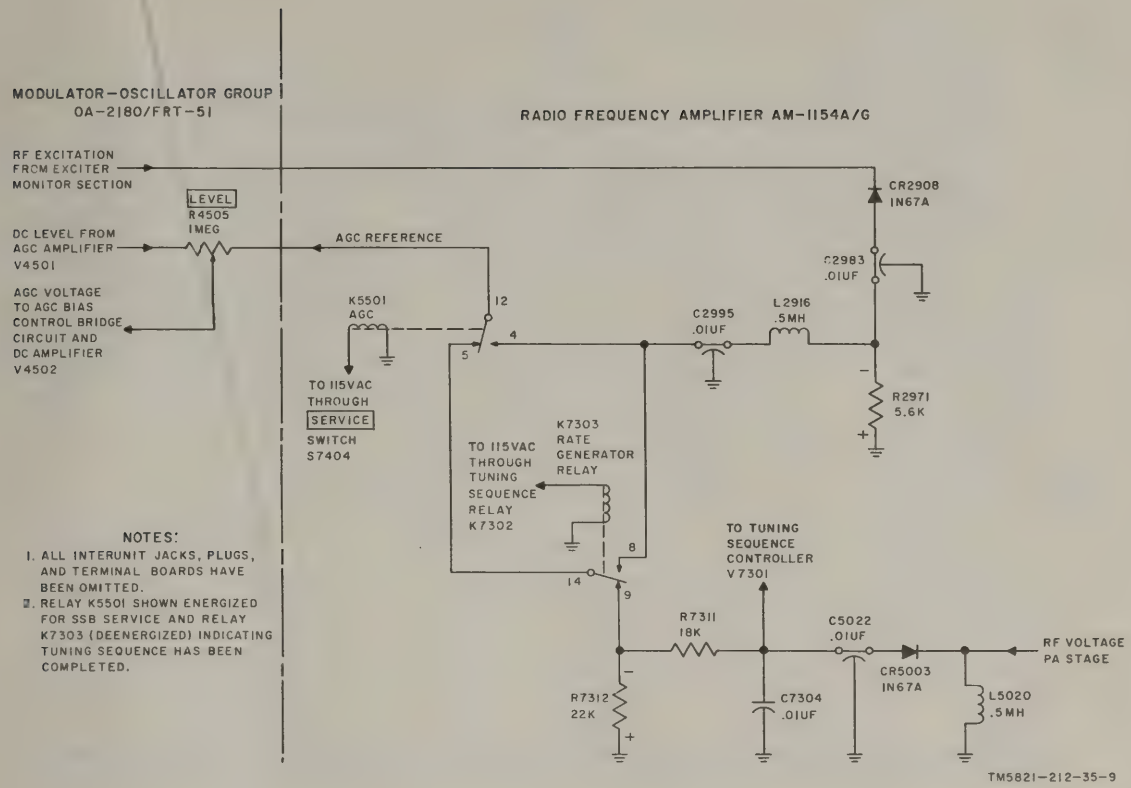

MODULATOR-OSCILLATOR GROUP OA-2180/FRT-51
RADIO FREQUENCY AMPLIFIER AM-1154A/G
RF EXCITATION FROM EXCITER MONITOR SECTION
LEVEL R4505 1MEG
DC LEVEL FROM AGC AMPLIFIER V4501
AGC VOLTAGE TO AGC BIAS CONTROL BRIDGE CIRCUIT AND DC AMPLIFIER V4502
AGC REFERENCE
K5501 AGC
TO 115VAC THROUGH SERVICE SWITCH S7404
CR2908 IN67A
C2983 .01UF
C2995 .01UF
L2916 .5MH
R2971 5.6K
K7303 RATE GENERATOR RELAY
TO 115VAC THROUGH TUNING SEQUENCE RELAY K7302
TO TUNING SEQUENCE CONTROLLER V7301
R7311 18K
C5022 .01UF
CR5003 IN67A
RF VOLTAGE PA STAGE
L5020 .5MH
R7312 22K
C7304 .01UF
NOTES:
1. ALL INTERUNIT JACKS, PLUGS, AND TERMINAL BOARDS HAVE BEEN OMITTED.
2. RELAY K5501 SHOWN ENERGIZED FOR SSB SERVICE AND RELAY K7303 (DEENERGIZED) INDICATING TUNING SEQUENCE HAS BEEN COMPLETED.
TM5821-212-35-9

Figure 9. Rf amplifier and modulator-oscillator agc interconnections, partial schematic diagram.

19. Alc Interconnections
(fig. 10)

a. Tube V5004 is a reversed-biased diode that does not conduct until the pa output signal exceeds a predetermined level. When this level is exceeded, V5004 conducts to develop a bias voltage that controls the gain of V401 and V402 (fig. 10 and 16).

b. The cathode of V5004 is maintained positive with respect to ground by the voltage-divider action of potentiometer R2945. This cathode-to-ground voltage makes the cathode of V5004 positive with respect to the plate, and the diode cannot conduct unless the pa signal coupled through C5055 exceeds the cathode voltage.

c. When the pa output voltage exceeds the voltage selected by the setting of R2945, the diode conducts on positive alternations of the input signal. The rectified signal is filtered by R5044, C5053, C5044, R5043, R417, and developed across R416. The polarity of the dc voltage developed across R416 is negative with respect to ground. When ALC switch S401 is in the ON position, the voltage across R416 biases the first controlled gain amplifier V401. The 300-kc input signal to V401 is coupled through C401 and developed across R401. Capacitor C402 and R402 filter the alc voltage developed across R416.

d. This circuit effectively makes the gain of V401 a function of the pa output amplitude. The setting of R2945 determines what power amplifier output level will produce a negative voltage across R416, thereby reducing the gain of V401.

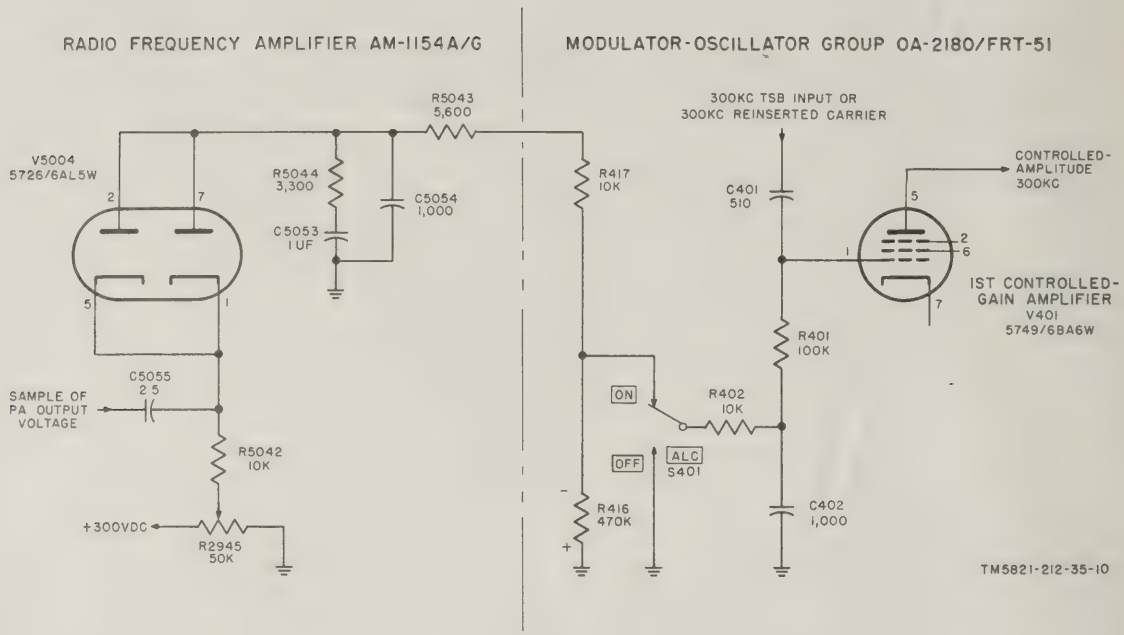


Figure 10. Rf amplifier and modulator-oscillator alc circuit interconnection, partial schematic diagram.

Section VI. ELECTRICAL DUMMY LOAD DA-212/FRT-51

20. Dummy Antenna
(fig. 11)

a. The dummy antenna serves as a load impedance for the transmitting set during test operations. It consists of a resistive network and a blower and interlock circuit.

b. Eight 100-ohm, 1,000-watt, series-parallel-connected resistors (R7501 through R7508) provide a 50-ohm load that dissipates the power output of the transmitting set. Rf meter M7501 is connected in series with the load resistors and measures the current flow through the dummy load resistors.

c. Two hundred and thirty volts ac is applied to blower B7501 through BLOWER ON-OFF switch S7502 and fuse F7501. The blower cools the dummy load and aids the resistors in dissipating the transmitter power output. Air switch S7501 is located in front of the blower and is closed by the airstream. The air switch is connected to the transmitting set interlock bus, and it prevents energization of the set unless blower B7501 is operating.

21. Rf Amplifier and Dummy Antenna Interconnections
(fig. 11)

Two connectors on the front panel of the dummy antenna connect the rf amplifier and hv power supply cabinets to the dummy antenna. Jack J7501 is connected to a 50-ohm coaxial cable that ties in to P5101 in the rf amplifier cabinet. The blower and interlock connections are brought in through P7502. The air switch leads are returned to terminals 8 and 9 of TB5503 and are in series with the door and thermal interlock circuit (fig. 45, TM 11–5820–350–35) of the hv power supply and rf amplifier. The blower is connected through TB5502 in the rf amplifier to terminals 7 and 8 of TB6003 (fig. 110, TM 11–5820–350–35) in the hv power supply cabinet.

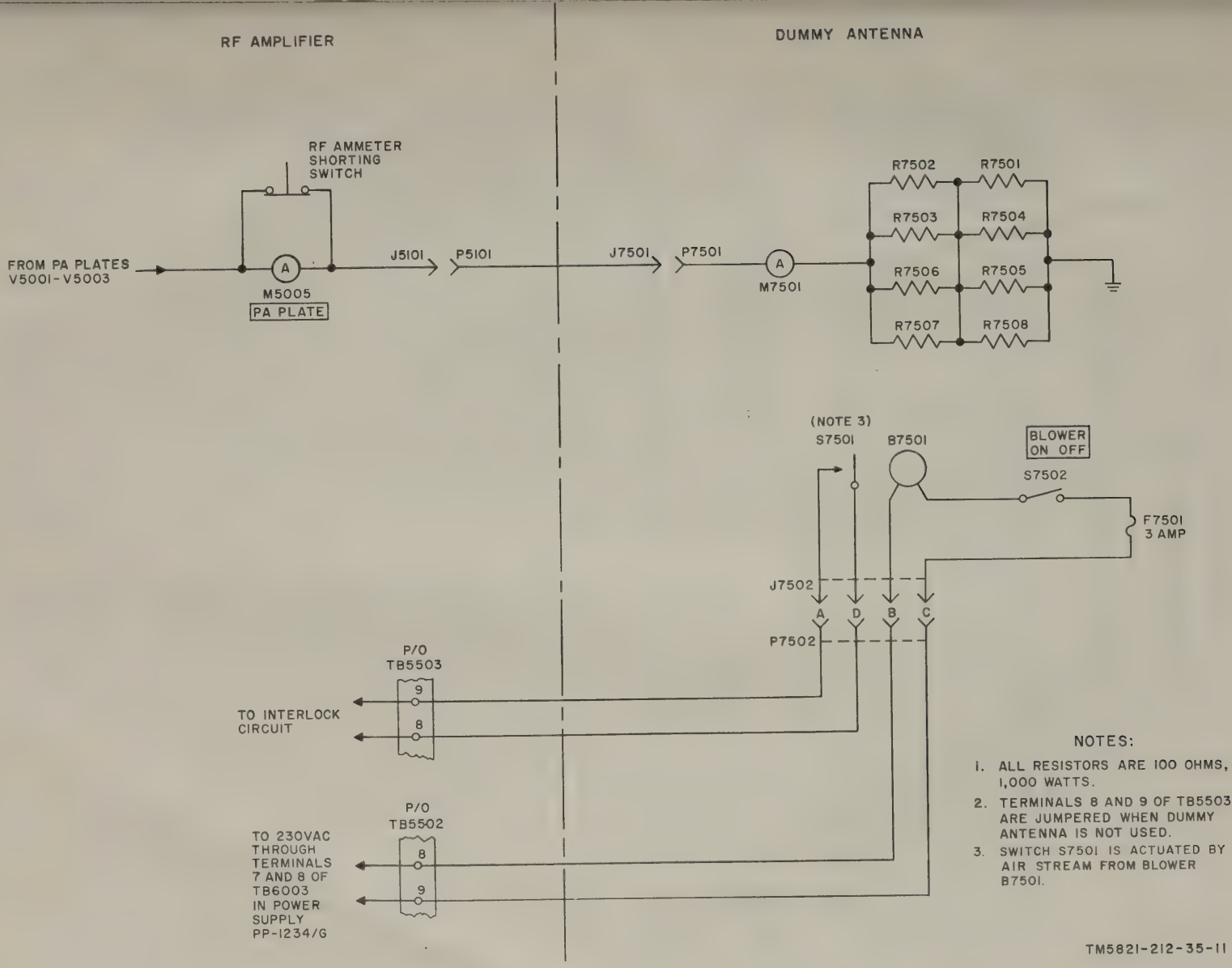


Figure 11. Dummy antenna, schematic diagram.

CHAPTER 2

TROUBLESHOOTING

Section I. TROUBLESHOOTING INFORMATION

Warning: Operation of this equipment involves the use of high voltages which are dangerous to life. Certain troubleshooting, alignment, and testing operations require energization of the equipment with the cabinet doors or drawers open to expose the high-voltage points. Whenever a door interlock, shorting switch, or other protective device is blocked, or otherwise disabled, there is extreme danger to maintenance personnel. Do not disable the protective devices unless it is absolutely necessary; remove all disabling equipment, such as interlock blocks, immediately after the maintenance procedure is complete. *Do not leave the equipment location while protective devices are disabled.* Before touching any component, turn off the equipment and ground the circuit. Voltages of 5,000 dc and extremely high rf exist in this equipment. Do not service alone. Do not depend on door interlocks and grounding switches for protection. Set the rf amplifier STANDBY switch to OFF whenever it is not absolutely necessary to operate the equipment while making measurements or tests.

22. General Instructions

Troubleshooting at field and depot maintenance levels includes all the techniques outlined for organizational maintenance and any special or additional techniques required to isolate a defective part. The field and depot maintenance procedures in this manual are confined to troubles within the interconnecting control circuits between the major components of the transmitting set. Field and depot level troubleshooting for Modulator-Oscillator Group OA–2180/FRT–51 is covered in TM 11–5820–215–35. Field and depot level troubleshooting for Control Amplifier C–1637A/GR, Radio Frequency Amplifier AM–1154A/G, and Power Supply PP–1234/G is covered in TM 11–5820–350–35. None of these field and maintenance procedures are complete in themselves, but supplement the procedures described in TM 11–5821–212–20. The systematic troubleshooting procedure, which begins with the operational and sectionalization checks that can be performed at the organizational level, must be completed by means of sectionalizing, localizing, and isolating techniques. Third echelon personnel are authorized to replace, but not repair, meters, gear assemblies, and servomotors. Refer to TM 11–5820–215–20P and TM 11–5820–350–20P for a complete list of maintenance functions.

23. Troubleshooting Procedures

a. General. The first step in servicing the transmitting set is to sectionalize the fault. Sectionalization in this equipment, should be performed by observation of front panel meters and panel lights. These indicators will sectionalize the defect to a particular compartment or subchassis. The second step is to localize the fault. Localization means tracing the fault to the defective circuit or part responsible for the abnormal condition. Some of the meters in this equipment, such as M2301 on the power supply front panel of the modulator-oscillator, and MULTIMETER M5004 on the rf amplifier front panel, may be switched into a number of circuits; this permits localization by use of these front panel indicators. Some faults, such as burned-out resistors, arcing, and shorted transformers, can often be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltages and resistances or by waveform observation.

b. Component Sectionalization and Localization. A group of tests arranged to simplify and reduce unnecessary work and to aid in tracing a trouble to a specific component is listed below. The simpler tests are used first; those that follow are more complex. For example, the trouble is traced to a major component of the transmitting set (rf amplifier, hv power supply, amplifier control unit, or the modulator-oscillator), and then the trouble is traced to a section within the major component, and the faulty part in that section is located and the trouble remedied. The service procedure is summarized as follows:

(1) *Visual inspection.* Visual inspection enables the repairman to locate faults without the use of external test equipment. All front panel meter readings or other visual signs should be observed. This inspection is valuable in avoiding additional damage that might occur through improper servicing methods.

(2) *Resistance measurements.* The use of resistance measurements to locate trouble will prevent further damage to the equipment if short circuits are present. The normal resistance values at any point can be determined by referring to the resistance values (para 66, TM 11–5820–350–35), or by using the schematic diagrams to calculate the resistance values, and by using the resistor color code (fig. 14). *Before making any resistance measurements, turn off the power and use a shorting stick to discharge any residual voltage.*

(3) *Voltage measurements.* Voltage measurements are an almost indispensable aid to the repairman because most troubles either result from or produce abnormal voltages. Normal voltages at tube sockets and key terminal points for the hv power supply and the rf amplifier supply are listed in paragraph 65, TM 11–5821–350–35. Voltage measurements in the modulator-oscillator may be made by using front-panel meters that indicate all power supply voltages and key voltages, and by checking voltages at test points that are located throughout the modulator - oscillator. The voltage values at these test points are listed in paragraph 120, TM 11–5820–215–35, along with references to waveforms where such information is applicable. Compare the readings obtained with the normal readings.

(4) *Operational test.* The operational test is performed by following the procedures of the equipment performance checklist in TM 11–5821–212–20. It is important because it frequently indicates the general location of the trouble. In many instances, the information gained will determine the exact nature of the fault. To use this information fully, interpret all symptoms in relation to one another.

(5) *Troubleshooting charts.* The troubleshooting charts in this manual list symptoms that could be the result of troubles within the control and interconnecting circuits. Once the trouble is sectionalized to a major component, reference is made to the troubleshooting chart in the manual (para 1*b*) covering the major component.

24. Troubleshooting Data

Detailed troubleshooting data for the complete transmitting set are located in the individual field and depot manuals covering the individual units that comprise the transmitting set. Use the material supplied in these manuals: TM 11–5821–212–20, where the equipment performance check and tube location diagrams are given; TM 11–5820–215–35, where troubleshooting data for the modulator-oscillator are located; and TM 11–5821–350–35, where troubleshooting data for the rf amplifier, hv power supply, and remote control unit are given. Consult the troubleshooting data below:

a. Troubleshooting Charts. The following listing locates the various troubleshooting charts:

Description	Paragraph	Technical manual
Modulator-oscillator power supply	115	11–5820–215–35
Hv power supply	64	11–5820–350–35
Automatic line voltage control	116	11–5820–215–35

Description	Paragraph	Technical manual
Frequency standard	117	11–5820–215–35
Tsb modulator	118	11–5820–215–35
Exciter-monitor:		
Smo and smo rf subchassis	119*a*	11–5820–215–35
Smo error detector	119*b*	11–5820–215–35
Phase lock indicator and 0.5-kc spectrum detent	119*c*	11–5820–215–35
Mixer-amplifiers	119*d*	11–5820–215–35
Monitor	119*e*	11–5820–215–35
Automatic tuning system	119*f*	11–5820–215–35
Ssb troubles	55	11–5820–350–35
Rf amplifier automatic tuning	58	11–5820–350–35
Control circuits	28	11–5821–212–35

b. Illustrations.

Description	Figure No.	Technical manual
Tube locations	28–33	11–5821–212–20
Hv power supply	86–93	11–5820–350–35
Modulator-oscillator power supply	73–75	11–5820–215–35
Rf amplifier	51–85	11–5820–350–35
Remote control unit	94	11–5820–350–35
Frequency standard compartment	79, 80	11–5820–215–35
Tsb modulator	91–101	11–5820–215–35
Exciter-monitor	103–125	11–5820–215–35
Automatic line voltage control panel	76–78	11–5820–215–35
Dummy antenna	11, 12	11–5821–212–35

c. Overall Schematic Diagrams.

Description	Figure No.	Technical manual
Hv power supply	110	11–5820–350–35
Modulator-oscillator power supply	155	11–5820–215–35
Main junction box	157	11–5820–215–35
Exciter-monitor junction box	154	11–5820–215–35
Rf amplifier	111	11–5820–350–35
Frequency standard	149	11–5820–215–35
Tsb modulator	150	11–5820–215–35
Exciter-monitor	151	11–5820–215–35
Automatic line voltage control	160	11–5820–215–35
Rf amplifier control circuits	45	11–5820–350–35
Interunit control circuits	16	11–5821–212–35

d. Measurements.

Description	Paragraph	Technical manual
Rf amplifier and hv power supply voltage and resistance values	65, 66	11–5820–350–35
Modulator-oscillator test point readings	120	11–5820–215–35
Ssb service test table, range of meter readings	80	11–5820–350–35
Dummy antenna corrected resistance	33	11–5821–212–35

25. Test Equipment

The test equipment required for troubleshooting the transmitting set is listed below.

Nomenclature	Common name
Frequency Meter AN/URM–80	Vhf frequency meter
Frequency Meter AN/URM–79	Rf frequency meter
Audio Oscillator TS–382A/U	Audio oscillator
Electron Tube Test Set TV–2/U	Tube tester
Electric Tube Test Set TV–7/U	Tube tester
Ammeter ME–65/U	Ammeter
Analyzer, Spectrum TS–723/U	Spectrum analyzer
Multimeter ME–77/U	Multimeter
Voltmeter, Meter ME–30A/U	Ac voltmeter
Multimeter, Meter ME–26A/U	Rf voltmeter
Oscilloscope OS–8A/U	Oscilloscope
Thermometer, 0–100° C, Weston 2661 (or equivalent).	Thermometer
Torque meter, 0–20 in./oz	Torque meter
Torque wrench, 0.5 in./lb, Sturtevant F160–1 (or equivalent)	Torque wrench
Capacity Voltage Divider HP–453A	Capacity voltage divider
Resistance Bridge ZM–4/U	Resistance bridge

26. Preliminary Tests

With the transmitting set connected for normal operation, operate it as described in the applicable portions of the equipment performance checklist in TM 11–5821–212–20. Listen for crackling or buzzing noises that indicate high-voltage arcing. Circuit breakers on the front panel of the hv power supply and fuses located in the rf amplifier chassis and the modulator-oscillator power supply protect the equipment against filament and B+ shorts. Check for smoke and the odor of burned or overheated parts. If smoke or odor is present, turn the set off immediately to prevent further damage.

Section II. TROUBLESHOOTING CHARTS

27. Interunit Control Circuits Troubleshooting

To diagnose trouble in the interunit control circuits, use the overall interunit control circuit schematic diagram (fig. 16) and the simplified schematic diagrams located in the theory section. A defect in the power supplies, rf amplifier, or the modulator-oscillator may cause severe distortion in the output, an error in output frequency, or no output at all. Faulty operation of a major unit can be detected by comparing the front panel meter readings with those listed in the technical manual covering the specific major component. When the fault appears in more than one major unit simultaneously, suspect the hv power supply (which serves as the ac source for the modulator-oscillator power supply compartment) or the interunit control circuits. When trouble is suspected in one of the power supplies, refer to the appropriate chart in the field and depot manual that covers the equipment. When trouble is suspected in the interunit control circuits, refer to the troubleshooting chart for interunit control circuits (para 28*a*).

28. Use of Troubleshooting Charts

The troubleshooting charts are supplied as an aid to locating troubles in the interunit control circuits and the dummy antenna. The charts list the symptoms that the repairman observes and indicate how to localize trouble quickly to a cabinet, compartment, or circuit. After the trouble has been localized to a stage or circuit, a tube check and voltage and resistance measurement of this stage or circuit ordinarily should be sufficient to isolate the defective part. For troubles pertaining to open circuit breakers and blown fuses, refer to the equipment performance checklist in TM 11–5821–212–20. If no operational symptoms are known, begin with item 5 of the equipment performance checklist and continue until the trouble is located.

a. Interunit Control Circuits Troubleshooting Chart.

Symptom	Probable trouble	Correction
1. Remote control unit does not turn on rf amplifier and modulator-oscillator plate circuits (both units may be turned on locally).	Open OFF/RESET switch S9702.	Check S9702 (fig. 4). Both sets of contacts are normally closed.
	Defective ON switch S9701.....	Check S9701. Refer to figure 94, TM 11–5820–350–35 for location of components in remote control unit.
	Poor connection at J9701.....	Check connections at J9701 and P9701.
2. PLATE ON switch S9701 at remote control unit turns on rf amplifier circuit only.	Defect in connections between remote control unit and modulator-oscillator.	Check all cabling between P9701 terminals 12 and 13 in remote control unit and J3601 terminals 8 and 10 of power control panel in modulator-oscillator (fig. 4).
	No ground connection or poor ground connection between switch contacts connected to J9701 terminals 12 and 13.	Check ground connection between switch contacts of S9701 and S9702 (fig. 4).
	Defect in plate power control circuit of modulator-oscillator.	Check PLATE OFF switch S3601. (Contacts should be normally closed.) Check relay K2302 (fig. 155, 11–5820–215–35). Refer to step 3 of modulator-oscillator power supply troubleshooting chart (para 115, TM 11–5820–215–35).
3. PLATE ON switch S9701 at remote control unit turns on modulator-oscillator plate circuits only.	REMOTE LOCAL switch at rf amplifier in LOCAL position.	Place REMOTE LOCAL switch to REMOTE.

Symptom	Probable trouble	Correction
	Defective interconnections between remote control unit and rf amplifier.	Check connections between P9701 in the remote control unit and TB5505 and TB7401 (fig. 4) in the rf amplifier.
	Defective OFF switch S7402 in rf amplifier.	Check S7402 (contacts should be normally closed).
	Defective relay in plate control circuit.	Check latch relay K7401 and plate relay K6002. Refer to figure 45, TM 11-5820-350-35, and check through contacts 4-12 of K7402, 7-13 of K7409, 5-12 of K7404.
4. Rf amplifier does not tune up on MANUAL or AUTOMATIC.	No excitation signal from modulator-oscillator.	Check carrier reinsert relay K7301 (fig. 5) in rf amplifier. (Contacts 5-12 must close when K7301 is energized.) Refer to figure 80, TM 11-5820-350-35 for location of K7301.
		Refer to figure 5. Check carier reinsert relay K201 and modulation disabling relay K202 in tsb modulator section of modulator-oscillator. Refer to step 1 of tsb modulator troubleshooting chart (para 118, TM 11-5820-215-35).
		Measure for signal input from modulator-oscillator at TP2905 (fig. 67, TM 11-5820-350-35). If input signal is present (2 volts ac) refer to step 1 of paragraph 55, TM 11-5820-350-35. If no signal voltage is measured, refer to step 1 of paragraph 119*d*, TM 11-5820-215-35.
	Defective cable connection in carrier reinsert bus.	Check for continuity between terminal 5 of K7301 to terminal 5 of K201 (should be 0 ohm). Refer to step 5 of equipment performance checklist (para 23, TM 11-5821-212-20) and proceed until trouble is localized.
	Defect in rf amplifier	Refer to step 57 of equipment performance checklist in TM 11-5821-212-20, and proceed until defect is localized.
5. Rf amplifier does not revert to TUNE power when CHANNEL selection at remote control unit or modulator-oscillator is made.	Open circuit in tuneup bus	Check from pin 3 of K7301 in rf amplifier to ground on modulator-oscillator (should be 0 ohm). If reading is infinity, check for defective connection between these two points or relay contacts 7-13 of K3801. If reading is normal, and if defect is in rf amplifier, refer to step 57 of troubleshooting chart in TM 11-5821-212-20 and proceed until trouble is localized.
	Defect in phase lock indicator circuit within exciter-monitor section of modulator-oscillator.	Refer to phase lock indicator troubleshooting chart (para 119*c*, TM 11-6820-215-35).
6. Transmitter does not tune up correctly on all bands.	Defect in mixer-amplifier section of exciter-monitor compartment of modulator-oscillator.	Refer to step 2, 3, 4, 5, or 6 (as applicable) or mixer-amplifier troubleshooting chart (para 119*d*, TM 11-5820-215-35).

Symptom	Correction	Probable trouble
7. Channel selection may be made locally but not at remote control unit.	Defective REMOTE LOCAL switch S801 (fig. 109, TM 11–5820–215–35) in exciter-monitor section of modulator-oscillator.	Check contacts 1, 4, 7, and 10 for positive contact.
	Bad connection between remote control unit and modulator-oscillator.	Check connections between S9706 (fig. 94, TM 11–5820–350–35) in remote control unit and S801 in modulator-oscillator.
8. Transmitter does not tune up correctly. (Input (2 volts ac) to rf amplifier measured at TP2905 normal).	Poor connection or defective switch contact between S4403A and band-seeking switch S3102 in rf amplifier.	Refer to figure 6. There should be continuity between corresponding switch contacts on S4403A and S3102. If switches check normal, set TUNING switch to MANUAL and perform steps 57 through 77, paragraph 23, TM 11–5820–212–20. If transmitter performs normally on manual tuning, set TUNING switch to AUTOMATIC and perform steps 84 through 91, paragraph 23, TM 11–5820–212–20. If equipment does not perform normally in automatic mode, refer to paragraph 58, TM 11–5820–215–35.
	Defective tuning mechanism in rf amplifier.	
9. Transmitter output distorted when signal input changed from ssb to tsb.	Power amplifier stage overloaded. Alc network not functioning.	Check that alc switch S401 (fig. 37, TM 11–5820–215–35) is set to ON.
		Check V5004 (fig. 31, TM 11–5821–212–20) in pa stage of rf amplifier.
		Refer to figures 8 and 10. Make continuity check from pin 7 of V5004 (pa stage of rf amplifier) to pin 1 of V401 in tsb modulator compartment of oscillator-modulator (normal reading approximately 125K ohms). If reading is normal proceed to step 12 of tsb modulator troubleshooting chart (para 118, TM 11–5820–215–35).
10. Transmitter output distorted on ssb or tsb.	Agc voltage applied to mixer amplifier in exciter-monitor compartment of modulator-oscillator incorrect.	Refer to figures 8 and 9. Check components in agc reference bus between modulator-oscillator and rf amplifier. If a negative reference voltage is present at TP4505 (fig. 91 and 150, TM 11–5820–215–35) in tsb modulator compartment of the modulator-oscillator, refer to paragraph 132, TM 11–5820–215–35. If no negative reference voltage is measureable at TP4505, refer to step 4 of ssb troubleshooting chart (para 55c TM 11–5820–350–35).

b. Dummy Antenna Troubleshooting Chart. Faulty operation of the dummy antenna may be caused by a defective load resistor (R7501 through R7508). The faulty resistor usually can be localized by visual inspection. The load resistors are observed by removing (para 30) the top cover plate on the dummy antenna. Look for burns, cracks, and clouded areas in the graphite coating on the outside of the resistors. Faulty resistors sometimes can be located by watching for small arcs while rf power is applied to the transmitting set.

Caution: **The dummy load resistors, R7501 through R7508, must be handled with extreme care to avoid marring or scratching the graphite coating. Scratched or marred resistors quickly develop arcs and are ruined.**

Warning: **Avoid contact with the dummy load resistors while they are dissipating power, and for a short period after power has been removed.**

Symptom	Probable trouble	Correction
1. Transmitting set does not load correctly with dummy antenna.	Dummy antenna resistance changed.	Check the dummy antenna resistance by connecting a multimeter between the case and the center of J7501. The meter should indicate between 48 to 52 ohms. (The reading should be taken within a few seconds after the transmitting set is turned off, and before the load resistors have time to cool.) If the meter indication is incorrect, locate and replace the defective resistor (para 30).
2. Transmitting set does not come on when the PLATE ON switch is pressed.	Air interlock switch S7501 defective.	Turn off transmitter. Jumper terminals 8 and 9 of TB5503 in the rf amplifier. Press PLATE ON switch. If the transmitter comes on, *press the OFF/RESET button immediately* and locate defect in air switch S7501 circuit. If the transmitter does not come on, refer to step 68 of equipment performance checklist TM 11–5821–212–20.
		Remove P7502 from J7502 and the top cover of the dummy antenna. Close switch S7501 and measure the resistance between terminals A and D of J7502. The meter should indicate 0 ohms. Check connector and switch if reading is incorrect.
	Defect in blower circuit. (Noticeable by lack of airstream from blower.	Check fuse F7501. Check switch S7502. Check blower motor connections to B and C of J7502.

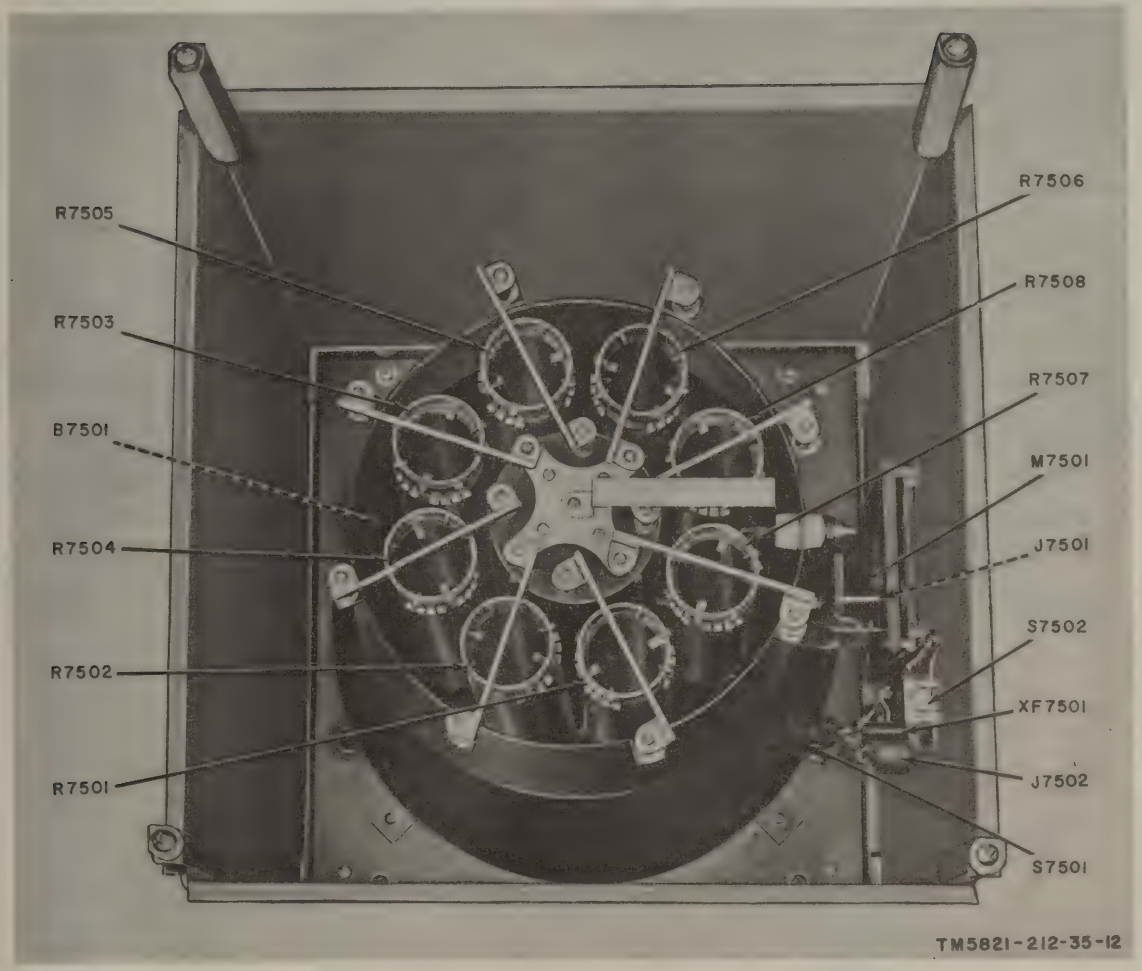


Figure 12. Dummy antenna, location of components.

CHAPTER 3

REPAIRS

29. Repair Procedures

Most of the components in the transmitting set are readily accessible and easily replaceable. Certain components in the rf amplifier cabinet and in the exciter-monitor section of the modulator-oscillator require special procedures for removal and replacement. The special procedures for the components in the rf amplifier are covered in paragraphs 69 and 70, TM 11–5820–350–35. The special procedures for the exciter-monitor components are covered in paragraph 122 through 124, TM 11–5820–215–35. The resistors in the dummy antenna require special handling. These procedures are detailed in paragraph 30.

Warning: **Before attempting any removal procedures, make certain that no power is applied to the transmitting set. Do *not* depend on shorting switches. Ground all circuits before touching them.**

30. Removal and Replacement of Dummy Antenna Resistors

(fig. 12)

a. Removal.

(1) Remove the two machine screws and the two lockwashers from the soldered contact bar and the attached resistor support bar on the defective resistor.

(2) Lift the soldered contact bar and the attached resistor support off the resistor.

(3) Lift the resistor out of the lower resistor support.

b. Replacement.

(1) Wrap a cloth around the replacement resistor and place the resistor on the lower resistor support.

Caution: **Do not toucr the graphite coating on the resistor.**

(2) Remove the cloth and replace the soldered contact bar and the attached resistor support on theresistor.

(3) Replace the two lockwashers and the two machine screws on the soldered contact bar.

CHAPTER 4

FINAL TESTING

31. Purpose of Final Testing

The final test procedures for the individual major components of this equipment are covered in the technical manuals that describe the major components. The procedures in paragraph 32 will determine the quality of the complete transmitting set. A repaired transmitting set that meets the requirements of the final tests in TM 11–5820/215–35, TM 11–5820–350–35, and the requirements listed in this chapter, will provide satisfactory operation equivalent to that of new equipment. If the equipment fails to meet the performance standards determined by these tests, refer to the applicable troubleshooting procedures in chapter 2.

32. Tuneup Sequence Test
(fig. 13)

a. Apply a two-tone test signal (3,000 and 5,000 cps) to one of the audio inputs (line 1 or line 2) of the tsb compartment of the modulator-oscillator group. Connect the equipment as shown in figure 13 and adjust the output of the audio oscillators to produce a 0 reading on the panel meter of the tsb modulator when the METER switch is in the +6 position and the LEVEL control set at 5. Adjust the 1,000-ohm resistor (fig. 13) to equalize the amplitude of the waveform peaks on the oscilloscope.

b. Connect the transmitting set to the dummy antenna.

c. Connect the ac voltmeter (para 26) to TP2905 (fig. 67, TM 11–5820–350–35).

d. Use the FREQ–KC, FREQ–MC, and BAND controls on the exciter-monitor compartment of the modulator-oscillator to set up 1.7 mc on channel 1 and 2.3 mc on channel 2. Set the CHANNEL selector switch on the remote control unit of 1.

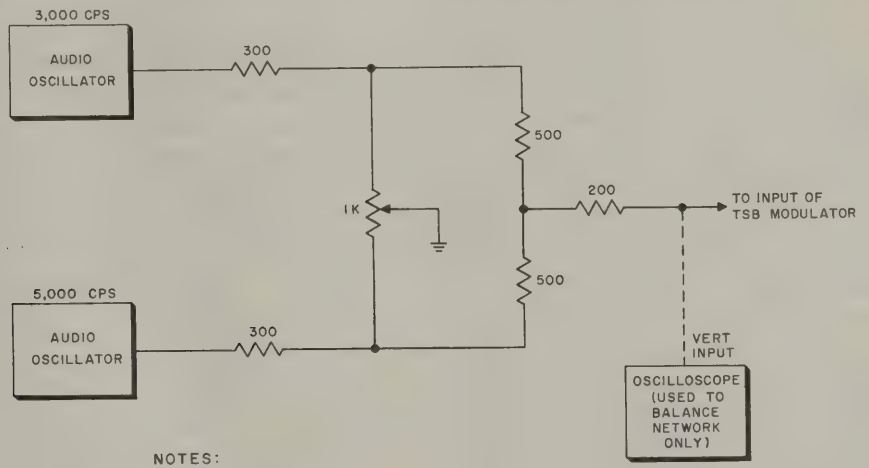


Figure 13. Tuning sequence test setup.

e. Energize the transmitting set in NORMAL POWER, SSB service, and AUTOMATIC TUNING.

f. Adjust LEVEL control R4505 (fig. 91, TM 11-5820-215-35) until the peak envelope power (pep) is approximately 4 kilowatts. Peak envelope power with the dummy antenna is calculated by doubling the average power. Average power is equal to the dummy antenna current meter reading squared, and multiplied by the corrected resistance (para 33) of the dummy antenna, or:

$$\text{Pep} = 2(I^2R \text{ corrected})$$

g. Note the meter indications on the PA PLATE, PA SCREEN, PA PLATE ammeter, rf ammeter, and the ac voltmeter that is connected to TP2905.

h. At the remote control unit, press the PLATE OFF button. Set the CHANNEL selector to 2 and press the PLATE ON button. The following sequence should take place:

(1) The red PLATE ON indicator lamps should light 25 seconds after the PLATE ON buttor is pressed.

(2) The blue STABILIZED lamp on the front panel of the power supply control of the modulator-oscillator should light within 5 seconds.

(3) The ac voltmeter connected to TP2905 should indicate approximately 2 volts. The rf amplifier should automatically switch to TUNE power, as indicated by the PA PLATE voltmeter, the PA PLATE ammeter, the PA SCREEN meter, and the rf ammeter that should show reduced readings.

(4) The rf amplifier should continue to tune up, as evidenced by sequential movement of the input amplifier tuning knob, the driver tuning knob, and the rf amplifier tuning and loading knobs. The rf amplifier group tuning should start immediately after the ac voltmeter indicates a reading. The rf amplifier tuneup should take approximately 5 seconds.

(5) When the procedure given in (4) above is complete the rf amplifier tuning and loading knobs should read just slightly and the meter reading should increase.

(6) The AUTO-TUNED indicators on the rf amplifier and the remote control unit should light.

i. The dummy antenna rf ammeter readings will vary during this test as follows:

(1) When the AUTO-TUNED lamps are extinguished, the meter reading will drop to zero.

(2) During the period that the rf amplifier is tuning up in low power, the meter reading will gradually increase to approximately 3 amperes.

(3) During the procedure given in *h*(5) above, the meter reading will increase to between 7 and 9 amperes.

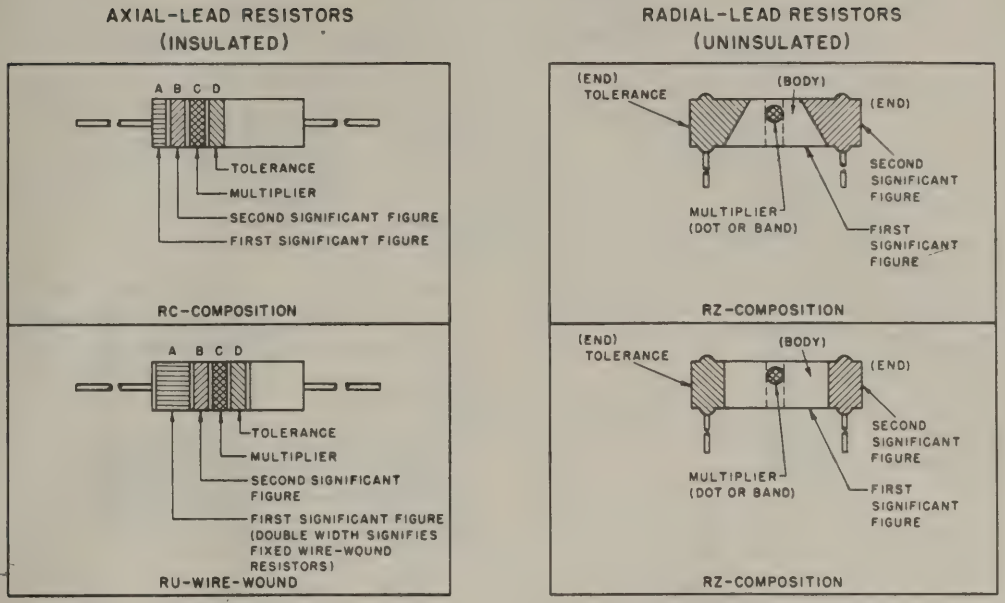
(4) When the AUTO-TUNED lamps light (indicating that the carrier reinsert relays K201 and K7301 (fig. 5) are deenergized), the meter reading will decrease to between 6 and 7 amperes.

33. Dummy Antenna Corrected Resistance

The resistance of the dummy antenna varies for different frequency inputs. To determine peak envelope power (para 32*f*), the exact resistance must be used. The table below indicates the dummy resistance for the range of frequencies used by the transmitting set.

Frequency (mc)	Series resistance	Frequency (mc)	Series resistance
1.5	49.5	10.0	50.1
2.0	49.6	12.5	50.3
2.5	49.7	15.0	50.6
3.0	49.8	17.5	50.9
4.0	49.9	20.0	51.4
5.0	49.9	24.0	52.3
6.0	50.0	28.0	53.5
7.0	50.0	30.0	54.2
8.5	50.0		

RESISTOR COLOR CODE MARKING
(MIL-STD RESISTORS)



RESISTOR COLOR CODE

BAND A OR BODY*		BAND B OR END*		BAND C OR DOT OR BAND*		BAND D OR END*	
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)
BLACK	0	BLACK	0	BLACK	1	BODY	± 20
BROWN	1	BROWN	1	BROWN	10	SILVER	± 10
RED	2	RED	2	RED	100	GOLD	± 5
ORANGE	3	ORANGE	3	ORANGE	1,000		
YELLOW	4	YELLOW	4	YELLOW	10,000		
GREEN	5	GREEN	5	GREEN	100,000		
BLUE	6	BLUE	6	BLUE	1,000,000		
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7				
GRAY	8	GRAY	8	GOLD	0.1		
WHITE	9	WHITE	9	SILVER	0.01		

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

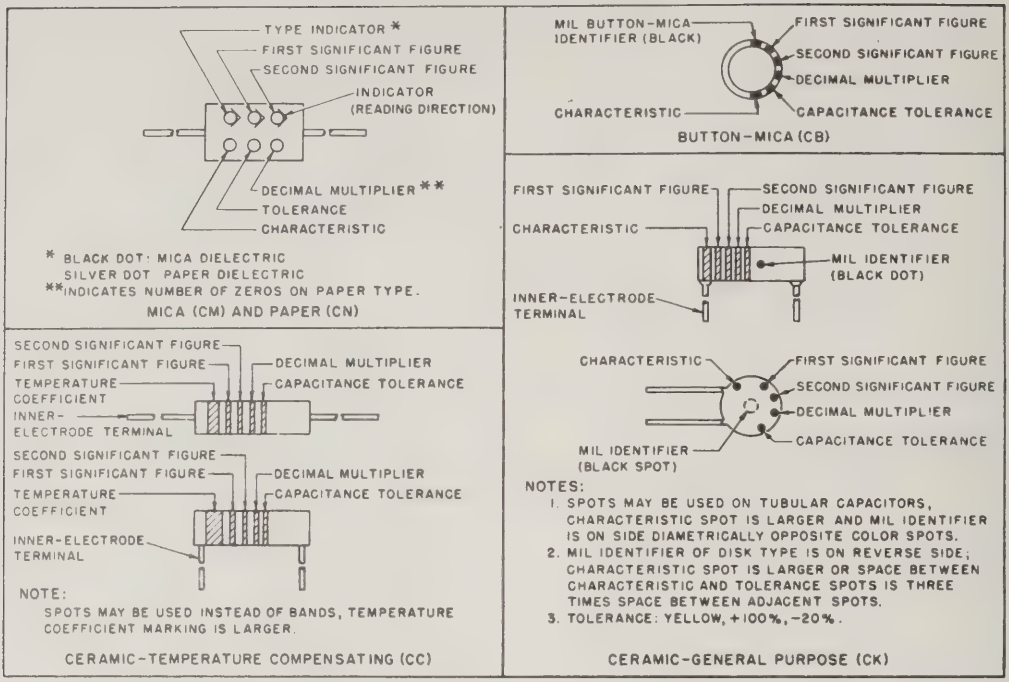
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END, RED DOT OR BAND; SILVER END.

STD-R1

Figure 14. MIL STD resistor color code.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



CAPACITOR COLOR CODE

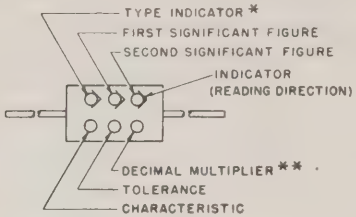
COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE[2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500)[3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

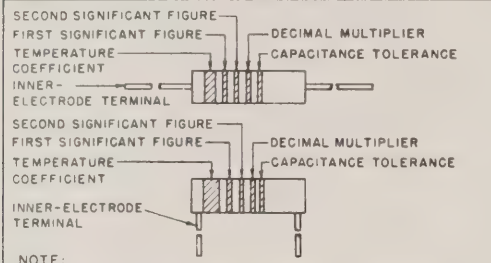
Figure 15. MIL STD capacitor color code.

CAPACITOR COLOR CODE MARKING
(MIL-STD CAPACITORS)



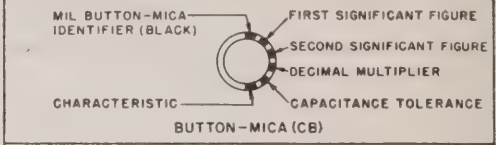
* BLACK DOT: MICA DIELECTRIC
SILVER DOT PAPER DIELECTRIC
**INDICATES NUMBER OF ZEROS ON PAPER TYPE.

MICA (CM) AND PAPER (CN)

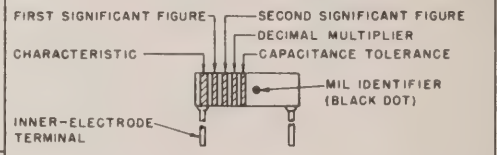


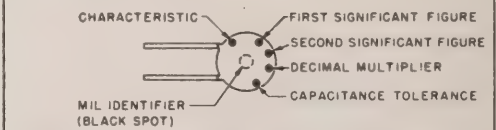
NOTE:
SPOTS MAY BE USED INSTEAD OF BANDS, TEMPERATURE COEFFICIENT MARKING IS LARGER.

CERAMIC-TEMPERATURE COMPENSATING (CC)



BUTTON-MICA (CB)





NOTES:
1. SPOTS MAY BE USED ON TUBULAR CAPACITORS, CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, -20%.

CERAMIC-GENERAL PURPOSE (CK)

CAPACITOR COLOR CODE

COLOR	SIG FIG.	MULTIPLIER		CHARACTERISTIC[1]				TOLERANCE [2]					TEMPERATURE COEFFICIENT (UUF/UF/°C)
		DECIMAL	NUMBER OF ZEROS	CM	CN	CB	CK	CM	CN	CB	CC		
											OVER 10UUF	10UUF OR LESS	CC
BLACK	0	1	NONE		A			20	20	20	20	2	ZERO
BROWN	1	10	1	B	E	B	W				1		-30
RED	2	100	2	C	H		X	2		2	2		-80
ORANGE	3	1,000	3	D	J	D			30				-150
YELLOW	4	10,000	4	E	P								-220
GREEN	5		5	F	R						5	0.5	-330
BLUE	6		6		S								-470
PURPLE (VIOLET)	7		7		T	W							-750
GRAY	8		8			X						0.25	+30
WHITE	9		9								10	1	-330(±500) [3]
GOLD		0.1						5		5			+100
SILVER		0.01						10	10	10			

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-C1

Figure 15. MIL STD capacitor color code.

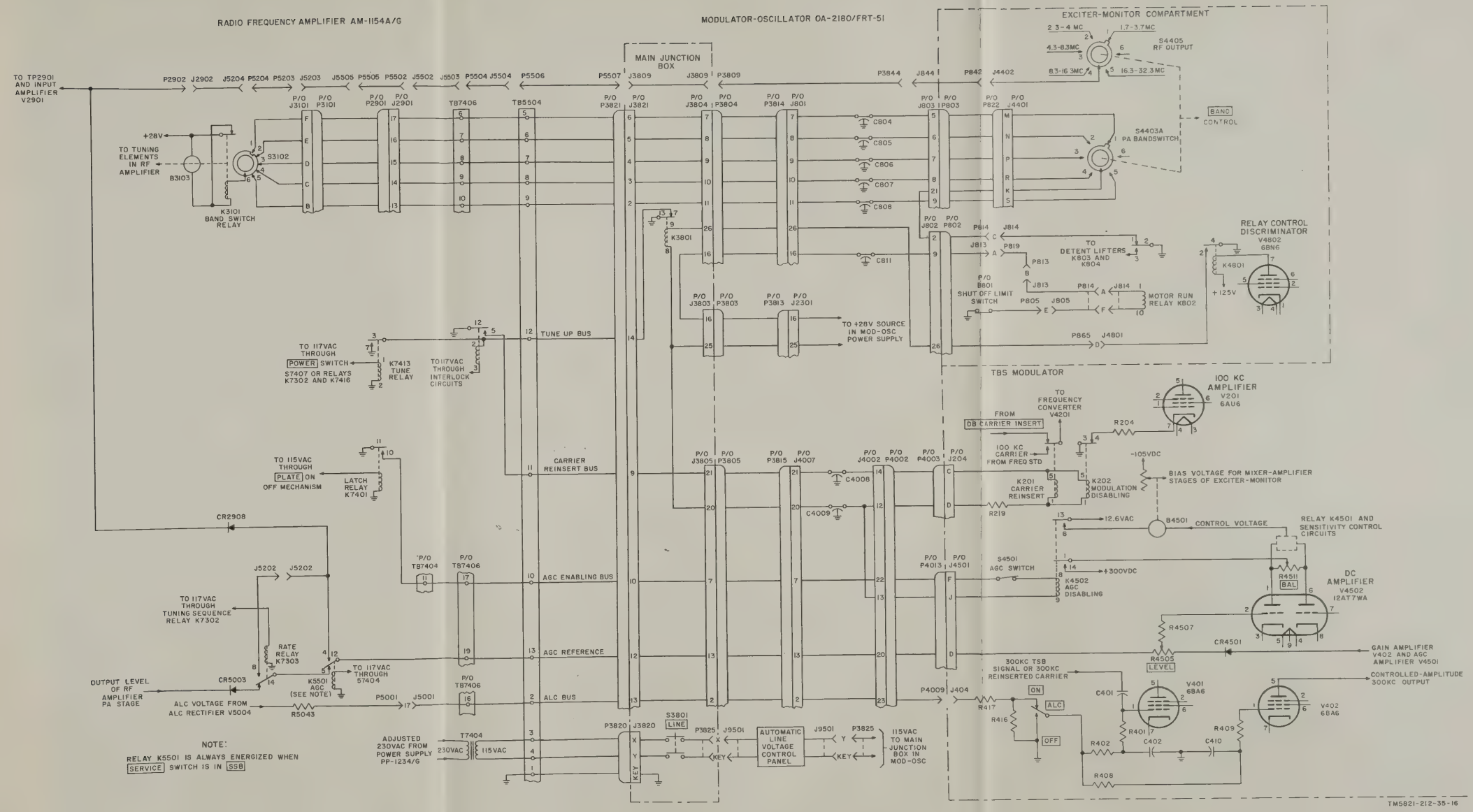


Figure 16. Rf amplifier-modulator-oscillator interunit control circuits, schematic diagram.

APPENDIX

REFERENCES

Following is a list of references applicable and available to the field and depot maintenance repairman of the transmitting set.

TM 11–856	Radio Receiver R–390/URR.
TM 11–1214	Instruction book for Oscilloscope OS–8A/U.
TM 11–2661	Electron Tube Test Sets TV–2/U, TV–2A/U, and TV–2B/U.
TM 11–5083	Electron Tube Test Sets TV–7/U, TV–7A/U, TV–7B/U, and TV–7D/U.
TM 11–5094	Frequency Meters AN/URM–79 and AN/URM–82.
TM 11–5095	Frequency Meter AN/URM–80.
TM 11–5097	Spectrum Analyzers TS–723A/U, and TS–723/U.
TM 11–5114	Panoramic Indicator IP–250/U.
TM 11–5132	Voltmeter, Meter ME–30A/U and Voltmeters, Electronic ME–30B/U and ME–30C/U.
TM 11–5820–215–10P	Operator's Maintenance Repair Parts and Special Tools List for Modulator-Oscillator Group OA–2180/FRT–51.
TM 11–5820–215–20P	Organizational Maintenance Repair Parts and Special Tools List and Maintenance Allocation Chart; Modulator-Oscillator Group OA–2180/FRT–51.
TM 11–5820–215–35	Field and Depot Maintenance Manual: Modulator-Oscillator Group OA–2180/FRT–51.
TM 11–5820–215–35P	Field and Depot Maintenance Repair Parts and Special Tools List; Modulator-Oscillator Group OA–2180/FRT–51.
TM 11–5820–218–12	Frequency Meter AN/TSM–16, Operation and Organizational Manual.
TM 11–5820–350–10P	Operator's Maintenance Repair Parts and Special Tools List for Amplifier, Radio Frequency AM–1154/G, AM–1154A/G, Control Amplifier C–1637/GR, C–1637A/GR/ Power Supply PP–1234/G.
TM 11–5820–350–20P	Organizational Maintenance Repair Parts and Special Tools List and Maintenance Allocation Chart; Amplifier, Radio Frequency AM–1154/G, AM–1154A/G; Control, Amplifier C–1637/GR, C–1637A/GR and Power Supply PP–1234/G.
TM 11–5820–350–35	Radio Frequency Amplifier AM–1154A/G, Power Supply PP–1234/G, and Control Amplifier C–1637A/GR.
TM 11–5820–350–35P	Field and Depot Maintenance Repair Parts and Special Tools List; Amplifier, Radio Frequency AM–1154/G, AM–1154A/G; Control, Amplifier C–1637/GR, C–1637A/GR and Power Supply PP–1234/G.
TM 11–5821–212–10	Radio Transmitting Set AN/FRT–51, Operator's Manual.
TM 11–5821–212–20	Radio Transmitting Set AN/FRT–51; Organizational Maintenance.
TM 11–5821–212–20P	Organizational Maintenance Repair Parts and Special Tools List; Transmitting Set, Radio AN/FRT–51.
TM 11–5821–212–35P	Field and Depot Maintenance Repair Parts and Special Tools List; Transmitting Set Radio AN/FRT–51.
TM 11–6625–200–12	Operation and Organizational Maintenance: Multimeter ME–26B/U.
TM 11–6625–203–12	Operation and Organizational Maintenance: Multimeter AN/URM–105, Including Multimeter ME–77/U.

Automatic load compensation (alc)—A dc voltage, derived from the linear power amplifier of a single-sideband transmitter, that is applied to the single-sideband generator. The alc voltage makes possible the use of full power output capabilities of the linear power amplifier when only one sideband is being used without danger of overloading when the other sideband circuit is put into use.

Balanced modulator—A modulator that produces both sidebands, but attenuates or eliminates the carrier signal.

Carrier level—The ratio of the carrier power output to the peak envelope power (pep).

Carrier signal—The frequency, which, when combined with signal frequencies in a demodulator, will reproduce the original intelligence applied to the input of the transmitter.

Carrier suppression—Carrier attenuation, expressed in db, below the peak envelope power of the desired sideband.

Conversion frequency—The frequency supplied to a frequency converter stage in the single-sideband generator for the purpose of converting the input signal to a new frequency.

Distortion—Amplitude of the third order intermodulation products, unless otherwise specified. This amplitude is expressed in db below the level of either of the two frequencies in two-tone excitation ($f_0 + f_1$, or $f_0 + f_2$) where f_0 is the carrier frequency and f_1 and f_2 are the two signal modulating frequencies of a two-tone excitation signal. Third order products result from the combination of either tone with the second harmonic of the other tone ($f_0 + 2f_1 - f_2$; $f_0 + 2f_2 - f_1$, etc).

Frequency standard—A stable crystal-controlled oscillator that is used as the primary frequency standard in a single- or twin-sideband system.

Independent-sideband transmitter—See twin-sideband transmitter.

Mixer-amplifier—A device that changes the frequency and provides amplification to an input signal. The output frequency is obtained by addition or subtraction of two frequencies instead of multiplication.

Noise level—Residual noise and hum level, expressed in db, below either one of the two equal tones required for rated peak envelope power output.

Peak envelope power (pep)—The power that is equal to twice the average power of the single-sideband transmitter when a two-tone test signal is applied to the single-sideband generator.

Pilot carrier—A single frequency that is transmitted for purposes of synchronization or adjustment of receiving equipment.

Single-sideband transmitter—A transmitter in which one sideband is transmitted and the other is attenuated or eliminated.

Twin-sideband transmitter (also referred to as an independent-sideband transmitter) — A transmitter where the sidebands on either side of the carrier contain separate information and where the carrier signal is attenuated or eliminated.

Two-tone test signal—A test signal that contains two equal amplitude signals of different frequency (usually at 3,000 and 5,000 cycles per second).

By Order of *Wilber M. Brucker*, Secretary of the Army:

G. H. DECKER
General, United States Army,
Chief of Staff.

Official:

R. V. LEE,
Major General, United States Army,
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NG: None.
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For explanation of abbreviations used, see AR 320-50.